Archer Martin

1 p.l. 22 p. 2 fold. maps. 2 fld. plans. Q.

John Gastineau

Victoria Water Supply.

REPORT

: BY :

THOS. A. BULKLEY

CHIEF ENGINEER TO GOVERNMENT.

ADDRESSED TO

The Hon. The Chief Commissioner of Lands & Works,

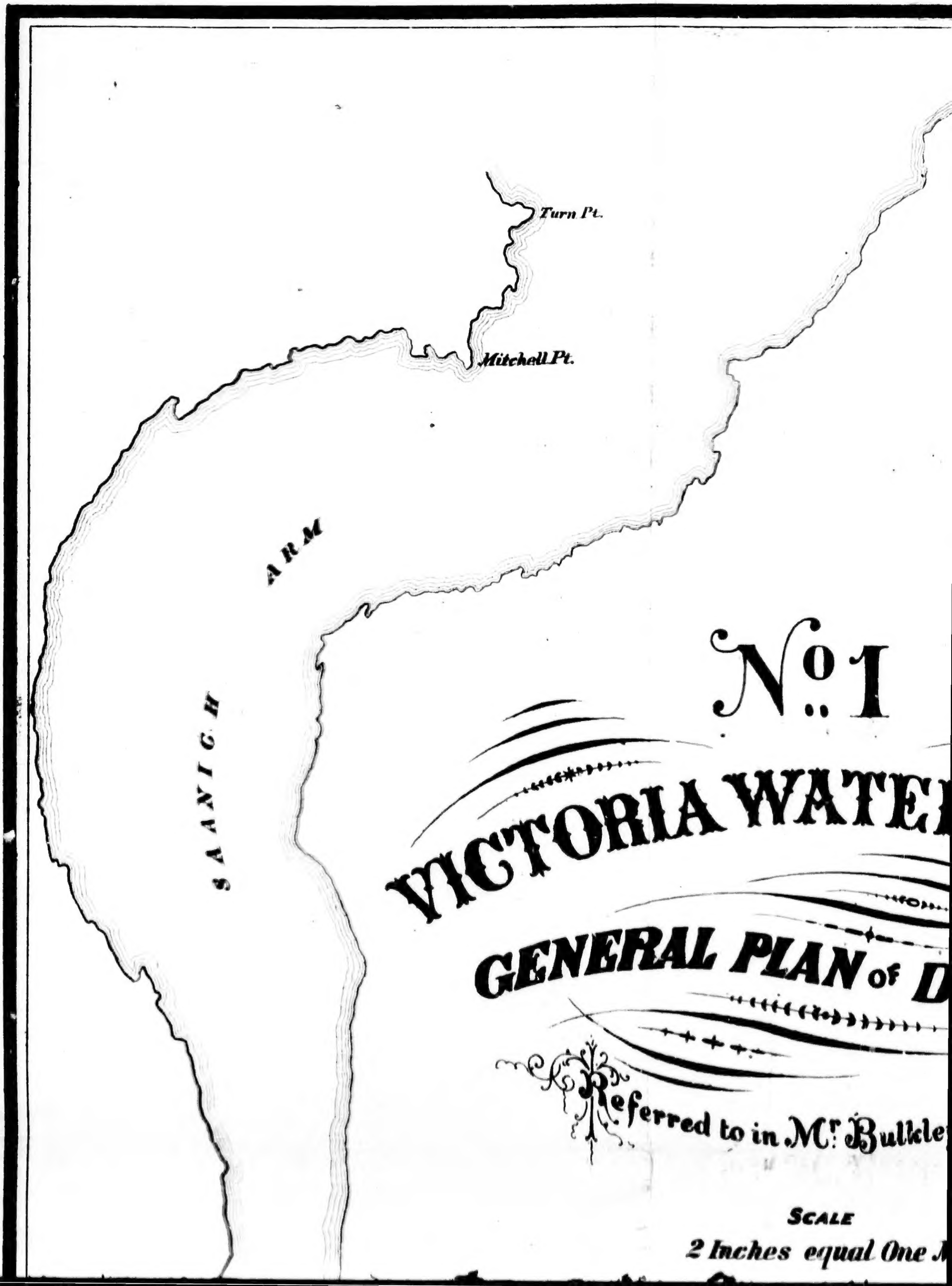
BRITISH COLUMBIA.

Dated, October 28th, 1872.

Victoria, B. C.

PRINTED AT THE "VICTORIA DAILY STANDARD" OFFICE.

1872.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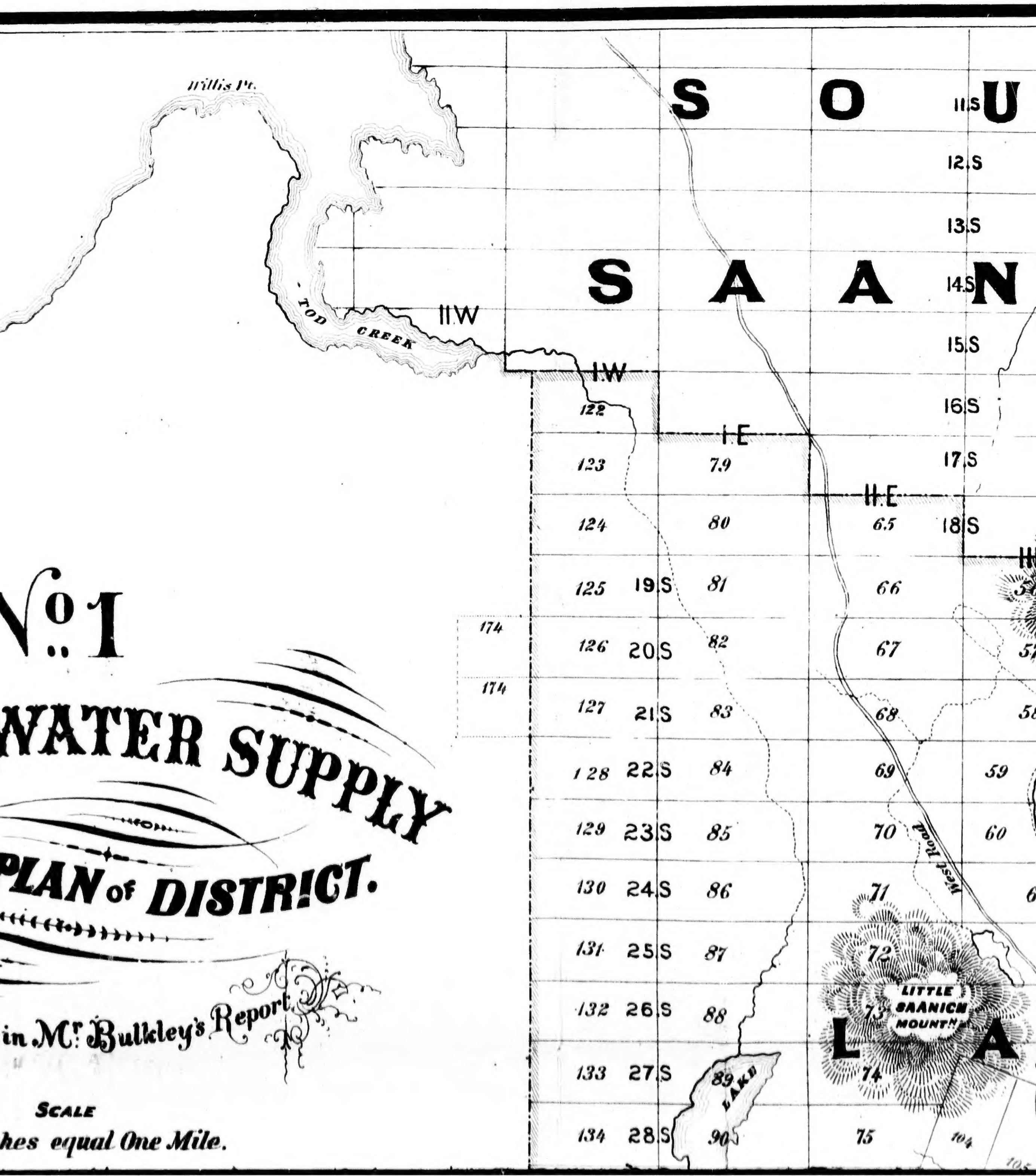

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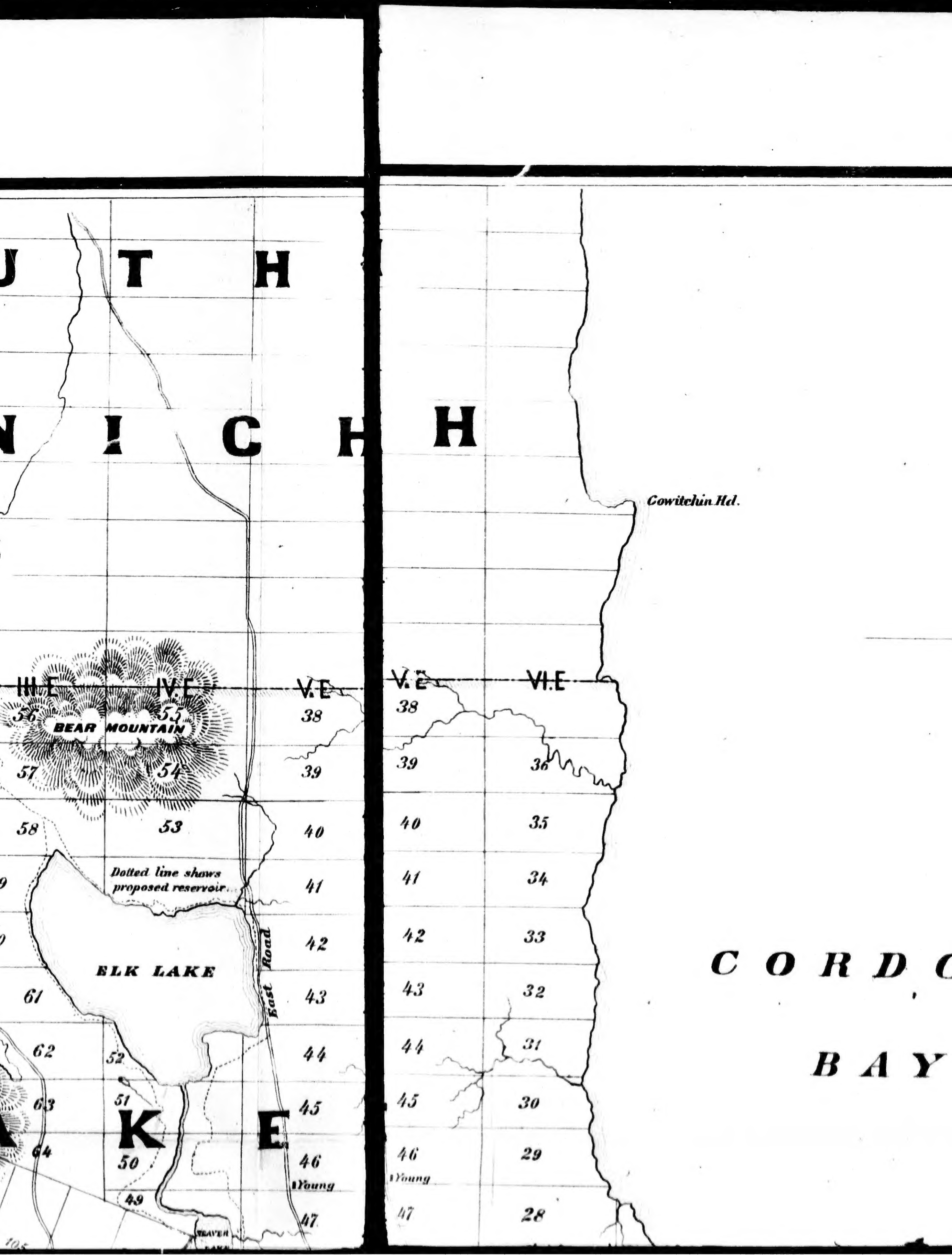
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Dotted line shows proposed reservoir
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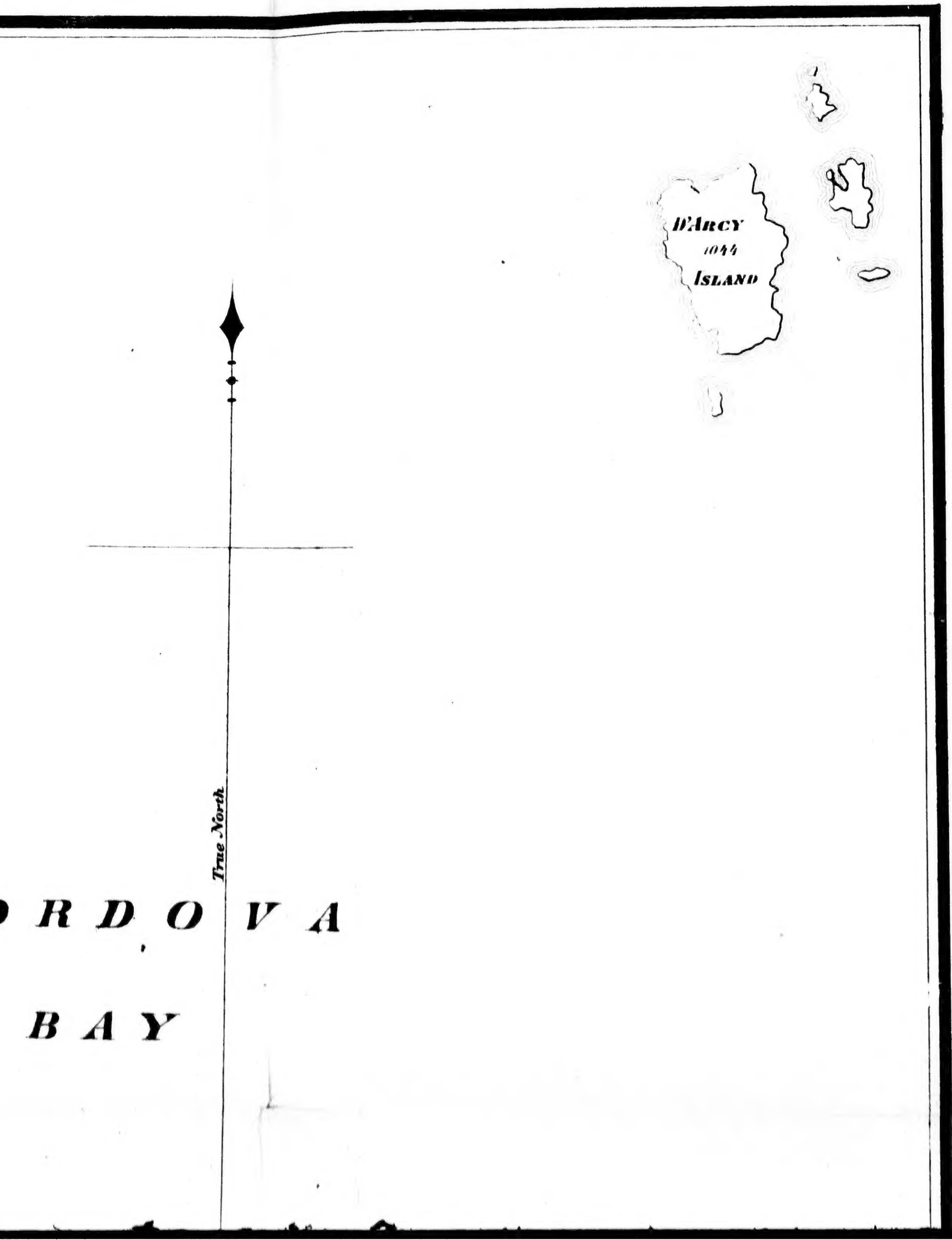
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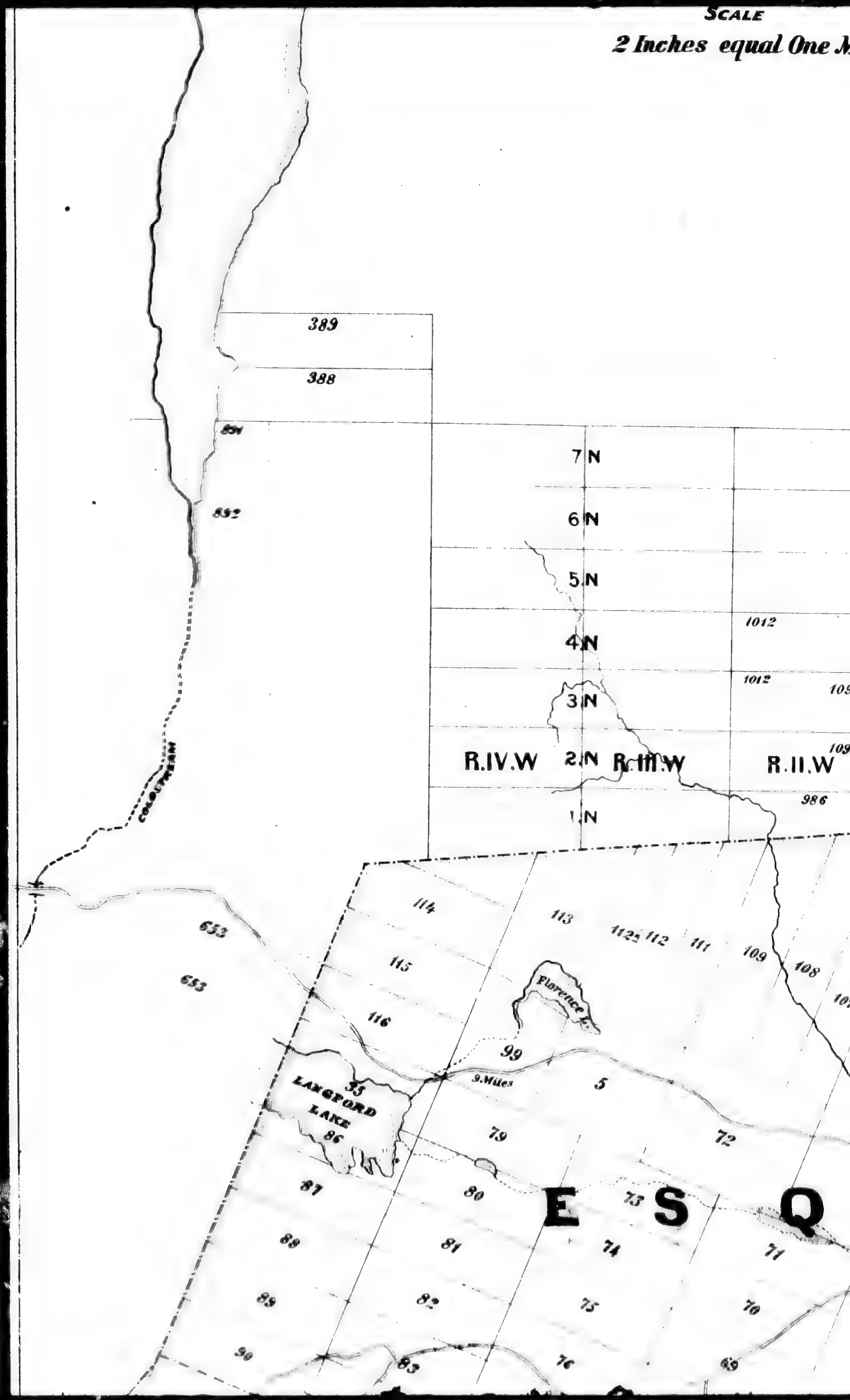
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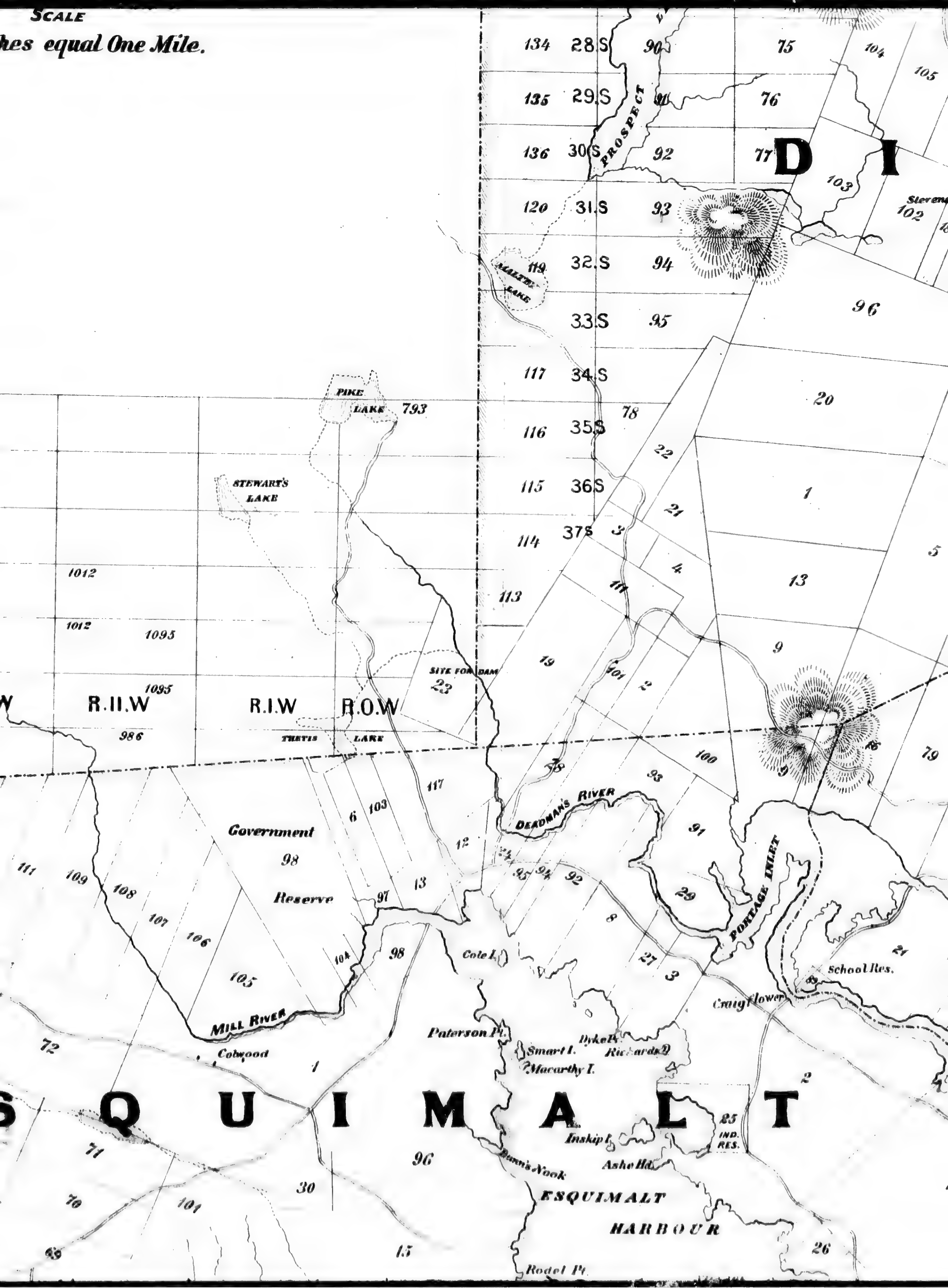

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R.I.W
R.O.W
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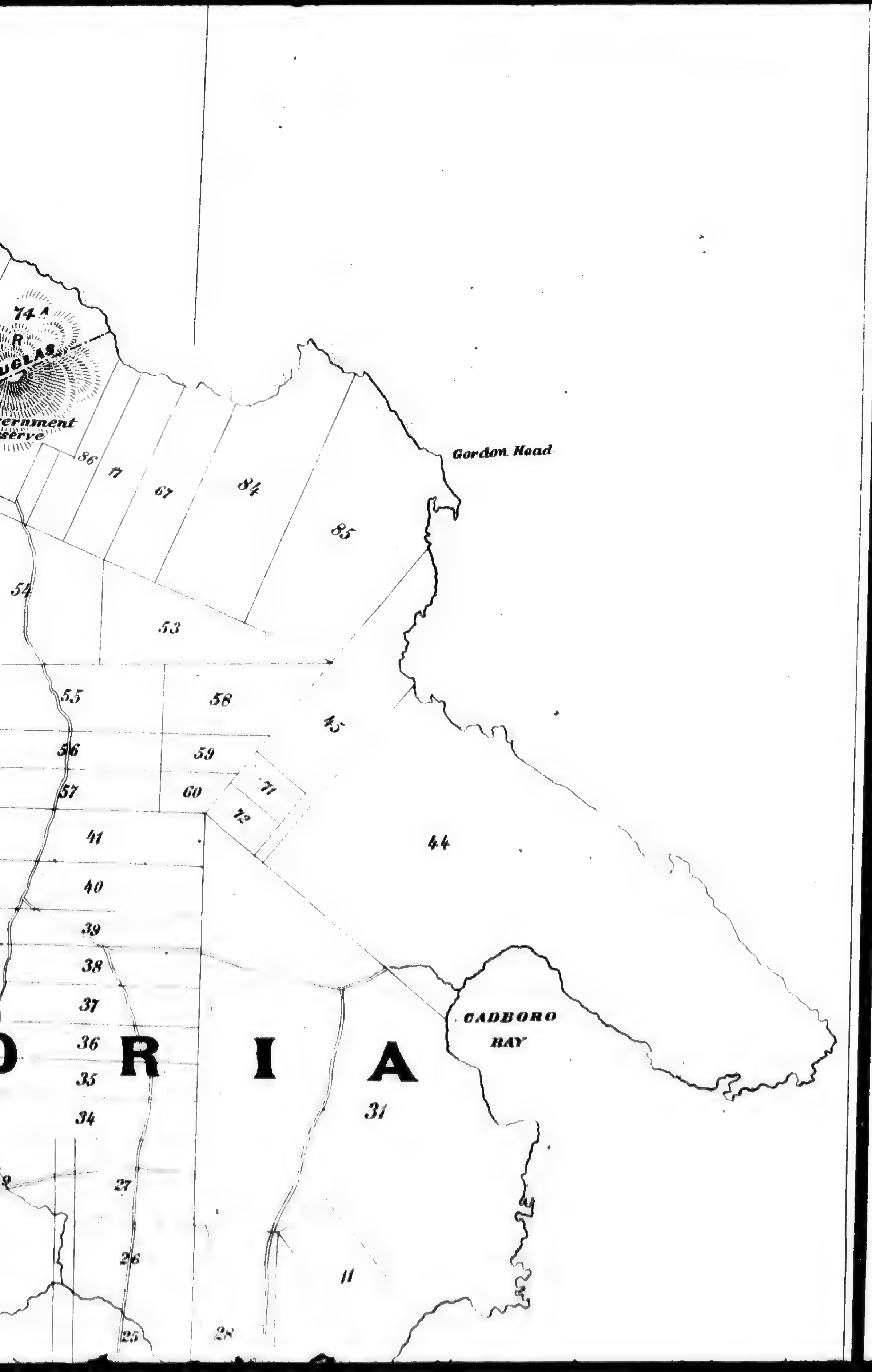
PORTAGE INLET
School Res.
Craigflower
MILL RIVER
Colwood
Paterson Pt.
Cole I.
Smart I.
Dyke Pt.
Macarthy I.
SQUIMALT
Inskip I.
IND. RES.
Ashe Hd.
ESQUIMALT
HARBOUR
Rodel Pt.

Beaver Lake
Proposed Dam
S T CT
Saw Mill
Manson
Royal Oak
Lindsay
Heald
Colquitz Stream
Swamp
100 Foot
Van Albuan
Line of Pipe
McKenzies Farm
Saanich Road
Swan Lake
Lost L.
Mount Douglas
Government Reserve
VII. E
Sub 1st.
V I I C T O R
Burnside
Road
The Gorge
Bridge
Sooke Road
Victoria Arm
Rock Bay



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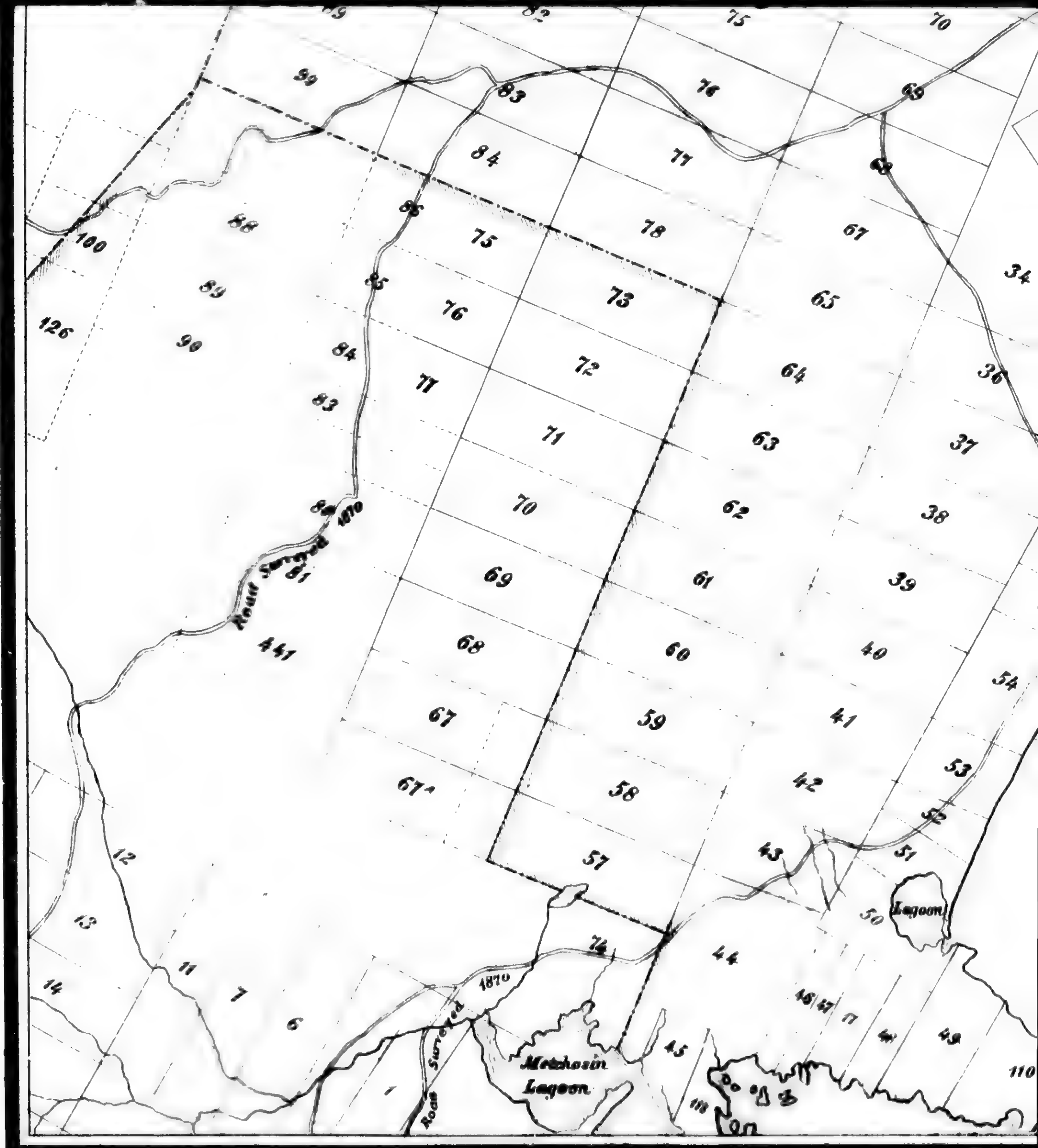
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Road Surveyed 1870
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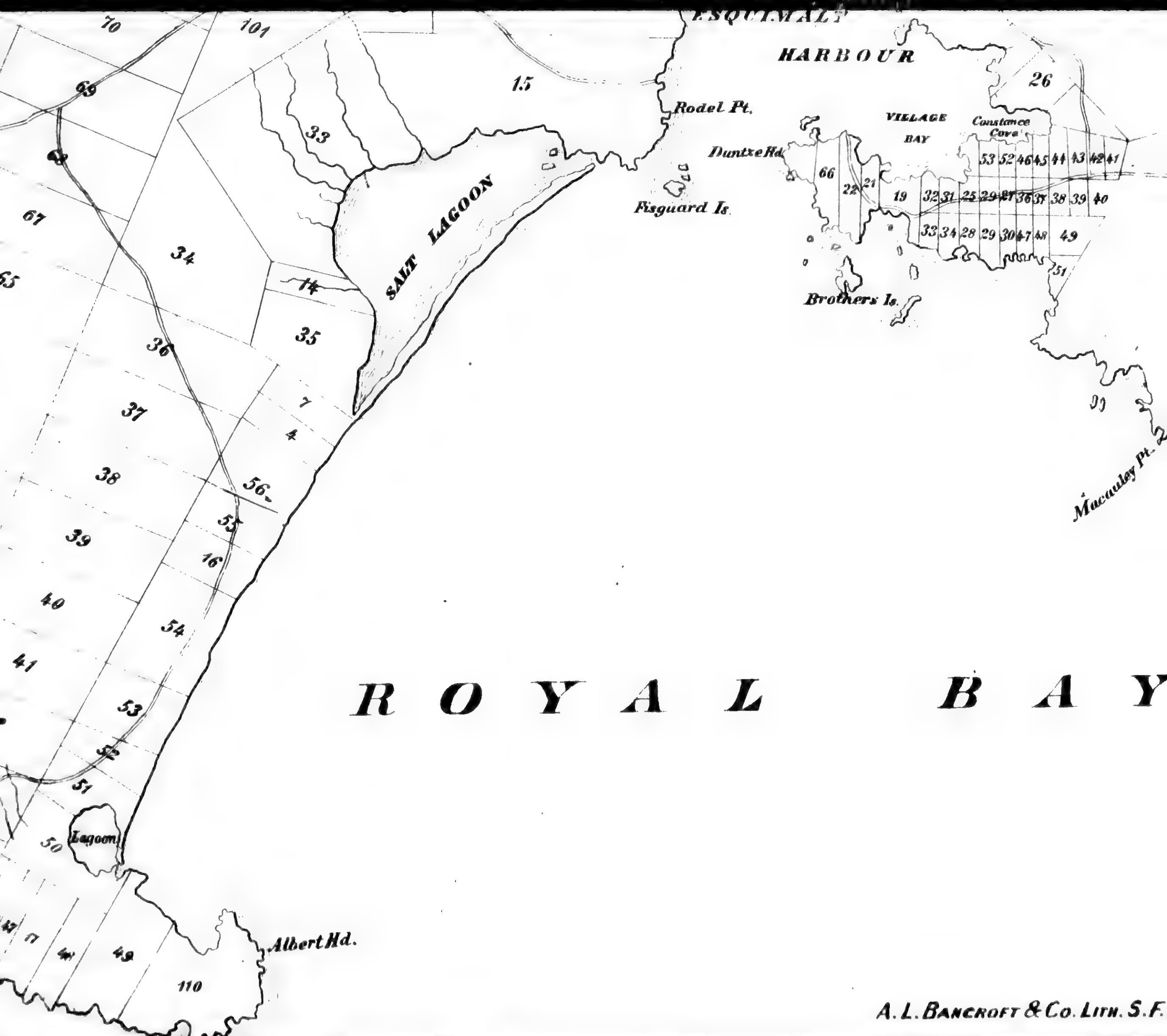
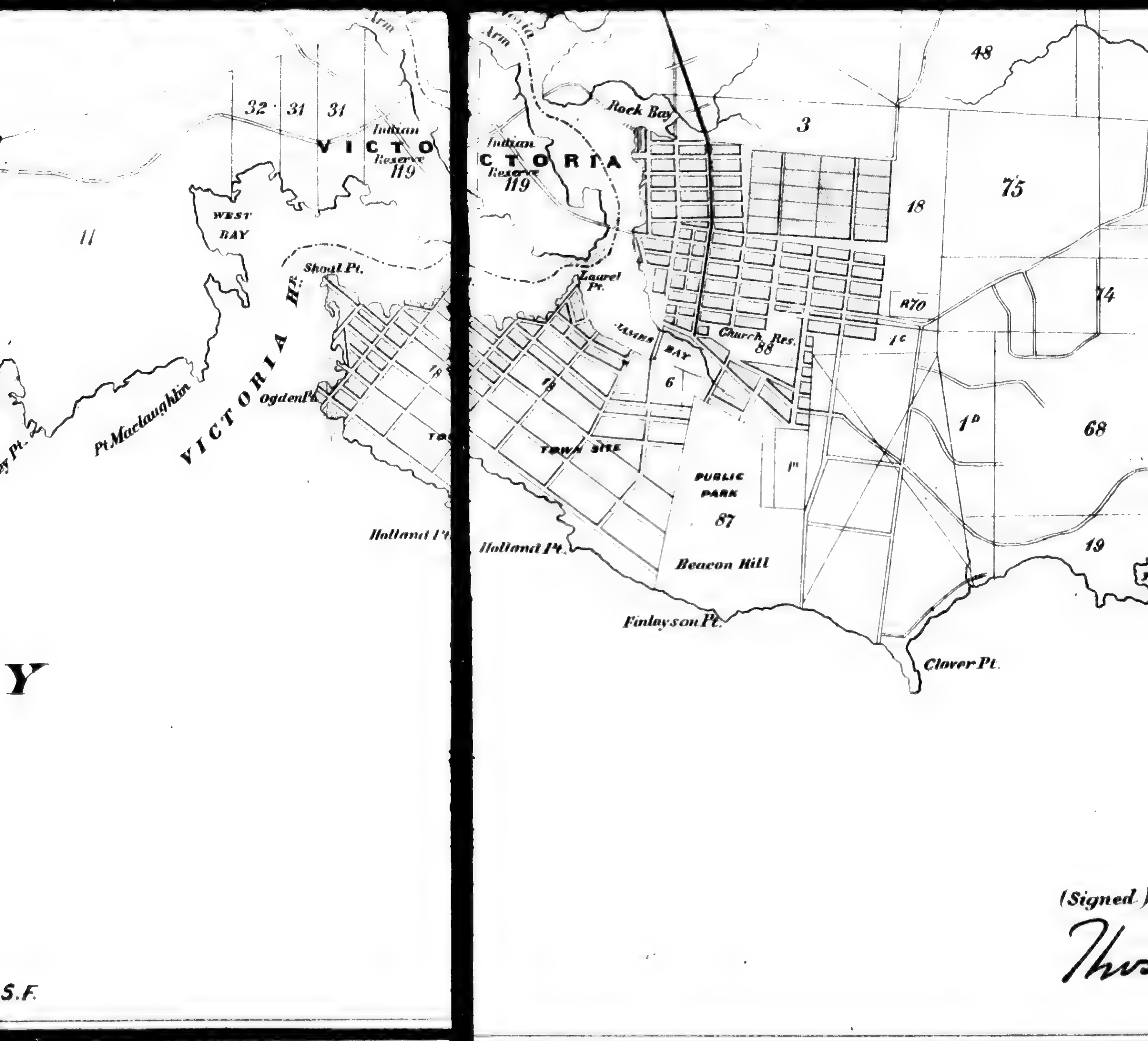


HARBOUR
Rodel Pt.
Duntze Hd.
Fisguard Is.
VILLAGE BAY
Constance Cove
Brothers Is.
SALT LAGOON
Macauley Pt.
ROYAL BAY
Lagoon
Albert Hd.
A. L. Bancroft & Co. Lith. S.F.



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Indian Reserve 119
VICTO
CTORIA
Indian Reserve 119
Rock Bay
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WEST BAY
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Shoal Pt.
Laurel Pt.
VICTORIA Hr.
Ogden Pt.
Pt Maclaughlin
VICTORIA
James Bay
Church Res. 88
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TOWN SITE
PUBLIC PARK
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Beacon Hill
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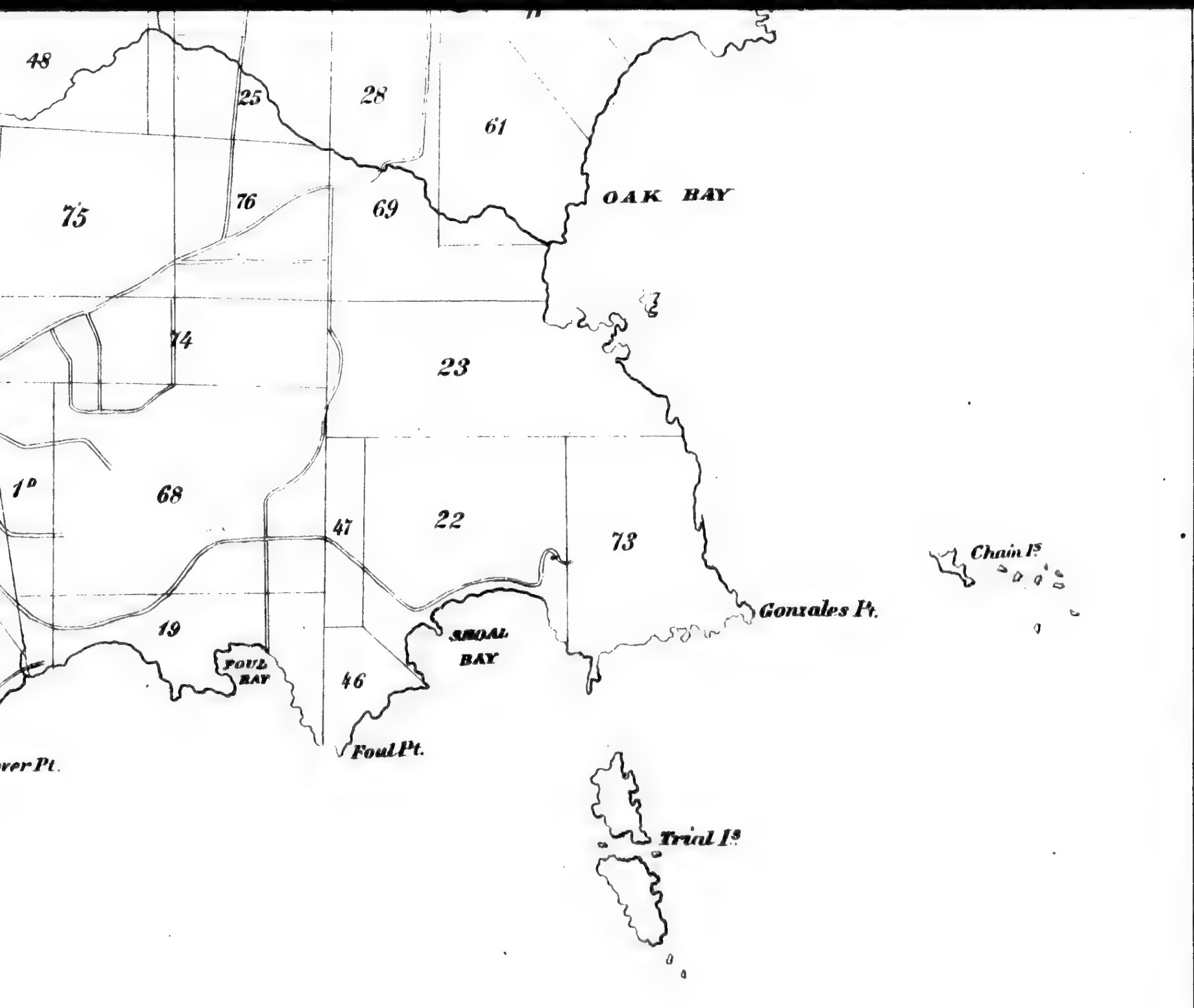

(Signed)

Thos. A. Bulkley

Chief Engineer to Government, British Columbia.

SIR:

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OFFICE OF CHIEF ENGINEER TO GOVERNMENT,
VICTORIA, BRITISH COLUMBIA.

THE HON. GEO. A. WALKEM,
Chief Commissioner of Lands and Works,

SIR:

One of the first questions requiring my attention, on entering upon my duties under the terms of your letter of the 24th of April, was that of the Supply of Water to the City of Victoria.

I have now the honor to submit my report on the subject, together with the result of my examinations, and Surveys, Plans and Estimates of the project, which I beg to recommend for your adoption.

Requirements for our water supply.

In the absence of any specially expressed instructions, the requirements which I proposed to myself were as follows:—

"A supply of water pure and soft, ample for existing requirements and capable of extension to meet the wants of such a considerably increased population as Victoria may reasonably expect.

A supply which shall be constant and on the High Service System and obtained, if possible, by gravitation in preference to pumping.

A supply to be obtained at the smallest cost compatible with efficiency; if possible at such an estimate as will enable the project to be financially self-supporting.

Water must be pure and soft.

The necessity for a supply of pure water is now, I imagine, more or less generally recognized; the advantage of "soft" water, however, in preference to "hard," on both healthful and economical grounds, is not as a rule so well understood.

The Report by the General Board of Health upon the supply of water to London abounds with evidence bearing upon this point.

Dr. Sutherland's evidence in favor of soft water.

Dr. Sutherland in his evidence states that he had examined the works for the supply of Gorbals, Paisley and Sterling, in all of which the water is obtained from gathering grounds and thence distributed: all these waters are described as "remarkably soft," Sterling water being only 1 degree of hardness, Paisley 2 degrees, and Gorbals about 8½ degrees, "and to a person accustomed to the hard water supply of London the sensation in washing is, that it can be done as well without soap in these waters as with soap in the London waters."

Again he remarks :—

"In those towns were a *soft* water supply has lately been introduced, I found a decided conviction prevailing among the medical profession as to the sanitary advantages of such waters, merely on the ground of their softness. The evidence goes to prove that dyspeptic complaints diminish, that epidemics are less severe and less fatal, and that stone and other calculous diseases are prevented."

Dr. Leech, of Glasgow, in the district supplied by the Gorbals Gravitation Water-works, said:—

"My attention has been called to the bearing of the question of pure soft water supply on the public health. The Gorbals water is very soft and pure. The new supply has been introduced about two years; but in consequence of the bad water supply which existed before the new water was introduced, my attention as well as that of my medical brethren was directed to the question for a long time previously. The comparative value of the new soft supply over the hard supply has been a matter of discussion at the Glasgow Southern Medical Society, of which I was president two years It was the unanimous opinion of the medical profession, that great benefits of a sanitary kind had followed in the substitution of the soft water on the principle of constant supply. It has been observed, that since this change, urinary diseases have become less frequent, especially those attended by the deposition of gravel. So far as experience has gone, my own opinion is, that dyspeptic complaints have become diminished in number. With the same reservation as to time, it is the opinion of the medical profession that fever has numerically diminished, and that the cases that occur are more amenable to treatment by the use of the soft water supply than they were with the former supply."

And again,

"I cannot therefore but express my conviction that in all towns where it may be found necessary to to obtain a new source of supply, this evidence as to the peculiar advantages of *soft* water in regard to health should apart from the well known economic value of such water, exercise great influence in determining the selection.

Dr. Holland's evidence in favor of soft water.

Dr. Holland, after describing a process in which he employed lime to effect the softening of hard water, was questioned as to whether it was worth while to go to so much trouble and expense for the sake of obtaining soft water; his reply was:—

"Certainly, it is very well worth while; in fact, without liming, I consider the water quite unfit for drinking; though it varies in quality, it has generally a very perceptible taste and smell which the lime removes. Then as to softness; I am charged 35*s.* a year for water (which is far too much), but, however, water costs me say 8*d.* a-week, but the soap for my family, in addition to that for the washing sent out, costs about 1*s.* 6*d.* a week, or twice as much as the water. It is evident that by diminishing the hardness of the water, and thereby the waste of soap, I may easily save the amount of my water-rate in that article alone. Besides that, I can wash comfortably with softened water, but I cannot do so with any quantity of soap with the water before it is limed, unless I have it boiled to precipitate the chalk, which process is more expensive and troublesome. I should, however, much prefer being supplied with a water fit for ordinary domestic purposes, and, if necessary, paying more for it.

"Have you tried the difference of hard and soft water for cooking?—I have not made any accurate experiments except as to tea making; I find that the water softened by means of oxalate of ammonia extracts the strength of tea almost twice as well as when hard. I had tea made with equal quantities of the lea', and equal quantities of boiling water, with and without oxalate of ammonia. The infusion made with water softened by the oxalate, was stronger and better flavoured, and had to be diluted with the addition 80 per cent. of hot water to bring it down to the strength of the other. It follows, therefore, that with the oxalate 10 parts of tea go as far as 18 without it.

"Does that saving pay for the expense?—Over and over again; my tea costs me about 1*s.* a week, if I can save eight parts out of 18, I can have as strong and better flavoured tea for less than 7*d.* a week,

being a saving nearly equal to the water rate. It is not easy, however, to get these savings effected regularly; it is apt to be forgotten, and cannot well be left to the servants. It would be far better to have a water originally soft, if it were procurable."

Dr. Lyon Playfair's evidence as to the domestic value of soft water.

Dr. Lyon Playfair, in the course of his evidence, when asked whether he had found reason to modify his opinion as to the domestic value of *soft water*, replied:—

"I speak with the force of increased experience when I say that I formerly greatly underrated the advantages of soft water. I need not allude to the importance of soft water for washing further than to say 30 ozs. of soap are consumed by every 100 gallons of Thames water before it forms a lather fitted for detergent purposes. The importance of soft water in cooking is less obvious, but no less ascertained to exercise an important influence on the culinary art. With regard to health, accurate observations have not yet been made, especially with reference to human subjects, but, on animals, the effect of hard water is very apparent. Horses have an instinctive love for soft water, and refuse hard water if they can possibly get the former. Hard water produces a rough and staring coat on horses and renders them liable to gripes. Pigeons also refuse hard water if they can obtain access to soft. Cleghorn states, that hard water in Minorca causes diseases in the system of certain animals, especially sheep. So much are race horses influenced by the quality of the water that it is not unfrequent to carry a supply of soft water to the locality in which the race is to take place, lest their being only hard water the horses should lose condition. Mr. Youatt, in his book called "The Horse," in remarking upon the desirableness of soft water for the horse, says, 'Instinct or experience has made the horse himself conscious of this, for he will never drink hard water if he has access to soft; he will leave the most transparent water of the well for a river, although the water may be turbid, and even for the muddiest pool.' And again, in another place, he says, 'Hard water drawn fresh from the well will assuredly make the coat of a horse unaccustomed to it stare, and will not unfrequently gripe or further injure it.'"

Mr. Soyer's evidence as to the value of soft water culinary purposes.

Mr. Alexis Soyer, the well known cook, gave the result of his experience as being entirely in favor of soft water over hard for all culinary purposes. From experiments made by him it appeared that it required one-fourth more time and fuel to cook vegetables or meat with hard than with soft water; that hard water was ill adapted for making soups and broths, that it was also very inferior in making bread and in brewing operations.

Lastly, in connection with the question of soft water, James Temple, Esq., of Paisley was examined, as follows:—

Mr. Temples' evidence in favor of soft water from gathering grounds

"What experience has there been at Paisley of the public use of waters of different qualities?—Previously to the introduction of the new water supply, the water used was spring water and river water. The spring water taken from the wells was very hard; the river water was comparatively soft, and was used for washing. A supply was afterwards obtained of yet softer water from gathering grounds, the water at present in use being of only two degrees of hardness. An Act of Parliament was obtained to supply the town with river water, as being much softer than well water, but on ascertaining that a still softer water might be procured, the townspeople allowed the Act to expire without availing themselves of the powers conferred by it. This softer water, obtained from gathering grounds, is now in use, and is of two degrees of hardness.

"What can you state as evidence of popular appreciation of the softer water now supplied?—The popular complaint is that it is sold at too high a price, and they think it no crime to steal it, and they do steal it whenever they can.

"May they have well water or river water without stealing?—Yes; they may.

"This soft water is, then, preferred to the well or river water?—Yes; for every purpose.

"For drinking?—Yes, for drinking particularly; for myself, when I come to London I think I shall not get a good drink of water until I again return to Paisley.

"Is the supply of water constant at Paisley?—Yes; by gravitation.

"Is the soft water considered superior for tea and washing?—For tea, there is not a lady in Paisley who would not give testimony as to its superiority. We find also in washing that we have a great saving not only of soap, but also of the wear and tear of clothes, from the greater rubbing occasioned by hard water."

These opinions all tend to prove that were a plentiful supply of soft water procurable at a *moderate cost*, the population of this city would not be backward in availing themselves of it in preference to the hard and frequently impure water from the generality of yard and garden wells.

Scale of hardness.

The degrees of hardness referred to, are in accordance with a scale devised by Professor Clarke and since generally adopted. Thus, by water described as of 1, 2, 6 or 10 degrees of hardness is intended the hardening effect that would be produced by dissolving respectively 1, 2, 6 or 10 grains of chalk in a gallon of water.

Comparative hardness of waters from various sources.

The result of an examination of various waters, was found by the "Board of Health" to be as follows:—

	No. of Specimens.	Average Hardness.
Well and Spring water............	264	25° .86
River waters.....................	111	13° .05
Water from Surface Collection....	49	4° .94

Quantity of water required is 25 gallons per head per day.

With regard, now, to the quantity of water required to render the supply "ample for existing demands." In estimating this I shall probably be sufficiently accurate in assuming the existing population at five thousand, for which I propose to allow 25 gallons per head per day.

The following table gives some particulars regarding the populations provided for and the water actually supplied by several existing water companies:

Table of particulars regarding the delivery of several existing Water Cos.

Name of Company.	Population supplied, estimated at 7 8 per. house.	Mileage of Pipes excluding house service.	Diameter of Pipes.	Quantity of water delivered annually for all purposes.	Quan. of water delivered per head per day.
New River Company...	650,000			6,570.000,000 gals.	28 gals.
East London Water Co	442 000	228	3 to 42 in.	3,222,753 876 do	20 do
Southwark & Vauxhall	271,939	380	2 to 27 in.	2,195,000,000 do	22 do
West Middlesex Co.....	190,944	150		1,216,929,812 do	17 do
Lambeth Co..............	182,488	135	2 to 23 in.	1,123,200,000 do	16 do
Chelsea Co.	163,768	134	3 to 18 in.	1,438,458.000 do	24 do
Grand Junction Co.....	109,652	80	3½ to 32 in.	1,289,184 930 do	33 do
Kent Co.....................	75,129	85	1½ to 24 in.	393,948,750 do	14 do
Hampstead Co...........	35,022	26	3 to 12 in.	156,020,000 do	12 do
Paisley Co.................	29,690			487,658,250 do	45 do
Glasgow North Co	325,000			3,832,500,000 do	32 do
do South or Gorbals Gravitation Co..	70,000			817,600,000 do	32 do
Stirling Co	10,305			48.897,285 do	13 do
Nottingham Co...........	35,000			248,200,000 do	19 do
Preston Co.................	78,000			277,400,000 do	[illegible] do
Philadelphia Co.........	240,000	115	12 to 22 in.	1,825,000,000 do	20 do

From this it will be seen that the quantity of water delivered, varied between 9 and 45 gallons, averaging about 24 gallons per head per day.

This is, however, for all purposes, including street watering, sewer flushing, fire extinguishing, and special supplies to manufactories, and including a very large proportion of waste.

From the evidence before the Board of Health it appeared that the quantity of water actually entering into consumption, was far below that pumped into the mains or drawn from the reservoir.

Quantity of water supplied to various towns in England and Scotland.

In Stirling the consumption in the better class of houses including washing, baths and water-closets, was found to be almost 5½ gallons per head per day.

A direct experiment made in a first-class house in Liverpool showed the actual consumption to be 7 gallons per head per day for all purposes.

A similar measurement at one of the Liverpool hospitals gave a result of 10 gallons per head per day.

Mr. Gale in a paper descriptive of the new Glasgow Water Works, on which he was Resident Engineer, states that "the quantity of water used in the manufacturing towns of Lancashire is about 20 gallons per head per day for all purposes.

"In Manchester with a population nearly the same as Glasgow it is 22 gallons, and the quantity sold for trade purposes is from 5 to 8 gallons per head per day.

"In Sunderland with a population of 130,000 it is 15 gallons, of which 3 go to manufactures.

"In Nottingham it is 17 to 18 gallons per head, of which 5 or 6 are sold for trade purposes."

The quantity, therefore, which I have mentioned above, viz.: 25 gallons per head per day, appears to be a sufficiently liberal supply for Victoria.

Annual supply required for our present population.

We require then for our assumed population of five thousand, a daily supply of 125,000 gallons, which is equivalent to 45½ millions of gallons per annum.

I will return to the question of a future extension of the supply after explaining the details of my project.

Advantages of "high pressure" and "constant supply."

The advantages of "High Service" and a constant supply are now so well known that they are adopted in all new works, and introduced where practical in old works in favour of the intermittent system.

Cisterns avoided.

The advantages of a constant supply are manifold. The expense of cisterns and their attendant annoyance and impurities are avoided. With cisterns of lead, exposed to the action of both air and water, poisoning is the result. While according to Dr. Angus Smith "if wooden cisterns are used pure water can never be obtained."

Poisoning of the water avoided.

Again, with a constant supply, the leaden service pipes are always kept full and consequently free from air; by this means the oxidisation of the lead and poisoning of the water is avoided.

Security against fire.

Among the advantages of "High Service" is that of greater security against fire. Fire pulgs can be provided at certain known intervals along the principal streets, and by means of a hydrant, hose and nozzle, a high pressure jet of water can be obtained without the intervention of a fire engine.

It is stated that, with proper arrangements, a jet may thus be thrown on a house within two minutes of its being found to be on fire, while according to Mr. Braidwood it took on an average in London "more than 20 minutes before an engine can be brought to the spot and set to work at a fire, and more than 30 minutes in other towns."

Surplus water at high pressure can be utilized as a mechanical power.

A high pressure jet affords the easiest means of cleansing house fronts, windows, side-walks, and of watering the streets; and with a high pressure, any surplus supply of water provides, at a small cost, a convenient mechanical power which can be utilized for turning lathes, chaff cutters, printing and other small machines.

Saving in servants labor.

Finally in this country of high wages and scarce servants it is of no small importance to be able to command a constant supply of water in the upper part of the house without the labor of carrying it.

Objections to the pumping system.

The great disadvantage of a supply of water by pumping as compared with a supply on the gravitation system, is that of expense; and not so much the prime cost of engines and machinery as the continual expense of pumping and maintenance.

Then the engines are liable to get out of order, and the result, unless they are in duplicate, is an interruption in the water supply.

Again, pumping as a rule, necessitates either an intermittent supply or considerable expenditure in the construction of distributing reservoirs.

Gravitating system is the simplest, cheapest and best.

There is no doubt then that a high pressure supply of water on the gravitating system, provides the maximum of convenience at the minimum of cost for maintenance.

In adopting the gravitating system certain things are necessary.

In order, however, to adopt this system, the following requirements must be satisfied:—

1. The reservoir or other source from which the supply is drawn, must be sufficiently high to command the highest point of delivery within the town.

2. The supply pipe must be sufficiently strong to resist the pressure of the required head, and of sufficient size to deliver, under the pressure of such head, the maximum quantity of water required at any time during the day.

Various sources of supply generally open to an Engineer.

In seeking for a supply under these conditions there may be said generally to be three sources open to one:—

1. From springs or wells, either ordinary or artesian.
2. From water of streams or rivers.
3. From the collection and storage of surface water, or rainfall.

Well water, hard and impure.

Under the 1st head may be classed the present insufficient supply to the town. A large proportion of houses have their own wells. In the

generality of these the water is very hard—in several the water is unfit for use, as must always be the case in a city in which cesspools are the rule—and with all there exists the disadvantage that the water has to be raised and carried by hand in all weather.

Spring Ridge Water Company. Present supply is unsuited to the wants of the town.

Lying to the north-east of Victoria is a rising ground of gravelly water bearing formation ; on this the present "Spring Ridge Water Company" have established a small pumping engine, by which water is raised from a shaft and tunnel, and conveyed to town in wooden pipes.

This Company does not appear to have received the entire support and confidence of the public. Possibly on account of the high charges levied. Possibly from the deficient quantity and inferior quality of the water supplied. Possibly from the small amount of convenience attending its use. Probably from a combination of all three.

Supply from the Spring Ridge is insufficient.

There is no doubt that a small supply of good water might be obtained from this "Spring Ridge," but that it would be quite inadequate to our wants is evident from the fact that in the summer months, when a pure supply of water is most required, the spring fails and the Company are obliged to draw upon what is known as Harris' Pond ; and any person who has noticed the appearance presented by the remains of this muddy pool in the months of August and September, will not wish me to look for an increased supply in that direction. From either source the Company has to contend against the great disadvantage of pumping ever gallon of water they deliver.

Artesian wells considered.

With regard to artesian wells, I have seen them urged more than once, by the local press, as the means by which a cheap and abundant supply of water could probably best be obtained.

One writer, I noticed, went so far as to urge the fact of an artesian bore in Chicago having struck water at a depth of one thousand two hundred feet, as a good reason for cur embarking in a similar undertaking here.

The fact is, that the success or failure of an artesian well is a question depending upon the geological formation of the district. Success depends upon the existence of a permeable, water bearing, stratum having an outcrop at some higher level, with a considerable surface exposed for the absorption of the rainfall. This stratum being underlaid and overlaid by others of a clayey or impermeable nature. A well or bore is then sunk to tap the water bearing stratum, and, when this is reached, the water is forced up by the hydrostatic pressure due to the higher level at which the rainfall was collected.

These conditions can only be fulfilled in a district composed of regularly stratified rocks of the Secondary or Tertiary formations. Whereas, here in Victoria, such strata as exist are broken through in every direction by outcrops of volcanic or primary rocks.

With reference, also, to time and cost, artesian wells, even in districts thorougly known, have frequently failed to answer expectations.

That at Grenelle was in progress for 10 years before water was struck; and that at Passy, estimated at one year at a cost of £12,000, was only completed in four years at a cost of £40,000.

Artesian wells will not satisfy our requirements.

I am of opinion, then, that we have no reasonable grounds for expecting success in sinking an artesian well for the purpose of obtaining a supply of water for this city.

Water from Rivers or Runing Streams is not available in our neighbourhood.

We come next to the second source, viz: the water of streams or rivers, and this must be in its turn abandoned, as we cannot be said to have any Rivers in our neighbourhood, and such streams as exist, present little more than a dry bed throughout the summer months.

Lastly, we have a source of supply in the surface collection and storage of rainfall.

Water from gathering grounds or surface collection of rainfall is the purest and best.

From this source is derived the supply to the three towns mentioned on page one as specially remarkable for purity: and indeed all the recent supplies in Scotland and elsewhere are derived from lakes or gathering grounds.

Dr. Paton's observations lead him to the conclusion that a supply of pure, soft water for towns "can only be accomplished by collecting the water from high grounds formed of trap or primitive rock."

Evidence in favour of water from gathering grounds.

Dr. Lyon Playfair said:—"The practice is extending of taking water from surface drainage."

"I have found surface waters decidedly softer than river waters."

"I would sooner take the surface waters if you could take them from a large extent of hill ground away from habitations and consisting of non-calcareous formations."

Plan adopted in examining various gathering grounds.

In examining into this source my plan has been to ascertain the various valleys, or natural lines of drainage debouching upon, or in the neighbourhood of the city; and to trace these upwards with a view to finding some natural basin, at a sufficient elevation, in which the maximum quantity of water could be collected and stored with the minimum amount of embanking.

Various lines of surface drainage in our neighborhood.

These various valleys may be enumerated as follows:—

1. "Goldstream."
2. "Colwood Stream—heading in Langford Lake."
3. "Millstream."
4. "Prospect Lake Valley."
5. "Deadman's River."
6. "Colquitz River."

In Goldstream there is a large supply of water of excellent quality. The discharge, however, is away from us into the Saanich Arm, and the valley offers no special facilities for the formation of a storage reservoir.

Goldstream and Langford Lake considered and rejected.

In connection with the second valley, Goldstream might be made a valuable source of supply. By intercepting the water at a distance of two or three miles up, the stream might be diverted into Langford Lake, and from that, as a storage reservoir, the water might be brought into town.

This scheme, however, would involve at the outset a heavy expense, on account of some 9½ miles of iron conduit pipe, in addition to the two or three miles of flume between Goldstream and the Lake. And I have not thought it necessary to go into details with regard to it.

"Millstream" which empties into the head of Esquimalt Harbor, has its source among the hills in the neighborhood of the Saanich Arm.

Millstream examined but does not suit our requirements.

A flume has been construced at its mouth, extending out to sufficiently deep water for a water schooner to lie alongside; by this means a supply is obtained for the ships of H. M Navy.

By tracing up Millstream Valley about three miles an elevation of some 200 feet is obtained, but at this point the area of the watershed is somewhat limited, and considerable embanking would be required for the formation of a storage reservoir.

Prospect Lake will not answer our purpose.

The Valley of Prospect Lake commences at Highland or Maltby's Lake; this discharges into Prospect Lake at a height of 150 feet above high water at Victoria. The waters of both overflow northwards into the Saanich Arm, and offer no special facilities for the object we have in view.

Deadman's River offers a fine supply of water.

The next on our list is the Deadman's River. This valley heads on either side of the Green Mountain, and discharges into the north-west head of the Victoria Arm.

Here is, undoubtedly, an extensive gathering ground, which would furnish a very large supply of excellent water. I was so pleased with what I saw of this valley that I devoted considerable time to its examination; and, on tracing it upwards, found a convenient site for the construction of a dam a little below the junction of the waters of Thetis Lake and Pikes Lake. See plan attached.

By this means a large storage reservoir might be formed, uniting the waters of Pikes Lake and Thetis Lake, and the length of supply pipe required would be, roughly, about seven miles.

However, upon making more detailed measurements I found that the dam would require to be some 490 feet long, by 49 feet high, involving rather heavy work. A very considerable track of land would be inundated by the reservoir, and the maximum elevation of water obtained would not be more than about 159 feet above Victoria high water mark.

Deadman's River abandoned in favour of Elk Lake Valley.

Having at that time ascertained that more favourable conditions were to be found in connection with the next and last mentioned source, I determined to abandon Deadman's Valley in favour of the Colquitz.

This river, which empties into the north-east head of the Victoria Arm, derives its water from several distinct gathering grounds.

Various gathering grounds feeding the Colquitz.

Firstly, from a line of surface drainage, heading in "Lost Lake," at a height of 85 feet above H. W. M., flowing on through "Swan Lake" at a height of 50 feet, and joining the Colquitz near Rowland's.

Secondly, from a large tract of swamp land near Fiterre's farm.

Valley of Elk Lake is the highest and most extensive gathering ground.

Continuing to trace up the valley, the stream, after crossing the West Saanich road, begins to rise rapidly, until, in the country round Beaver Lake and Elk Lake, we reach the highest and most extensive portion of the gathering ground.

This, as you are are aware, is the source which I have selected for our water supply.

Survey Party.

In carrying out the preliminary examinations which I have roughly sketched above, it was necessary to engage the services of a small survey party. This party, with Mr Robert Homfray, surveyor in charge, was now placed in camp in the vicinity of Elk Lake, in order to complete the more detailed surveys which were required.

Present height of water in Elk Lake.

The height of the natural water level of Elk Lake, above approximate high water mark in Victoria, was found to be 183 feet.

see P12

Areas of Elk and Beaver Lakes.

The area of the open waters of Elk Lake and Beaver Lake which are really one, although separated by a long stretch of willow swamp, is as follows:

Elk Lake	394	acres.
Beaver Lake	18	"
Total	412	"

The mean depth is about 30 feet.

Present depth of lakes does not much affect the question of supply.

The depth, however, is a point which does not affect the question of supply, except so far that, the greater the depth, the less is the growth of aquatic plants, and the greater the probable purity of water.

However great the depth below the natural outlet or overflow, the water is not available unless at considerable expense for pumping or tunnelling.

The depth of water which can be obtained *above* the natural outlet, is the question which concerns us.

Admirable site provided by nature for construction of an impounding dam and waste weir.

Some distance below the open water of Beaver Lake—at the point shown on plan—great natural facilities are presented for the construction of a masonry dam and waste weir. The overflow channel is very confined and runs over bed-rock.

Storage reservoir of 589 acres

Here at a very trifling cost for embanking, the open waters of Elk Lake and Beaver Lake can be united and a magnificent storage reservoir formed with a surface area of 589 acres, and a depth of 10 feet above the natural outlet level.

Giving us a supply for 100,000 inhabitants.

Assuming that only six feet, out of these ten, are available for supply, this reservoir will have a capacity of over 962 millions of gallons, or one

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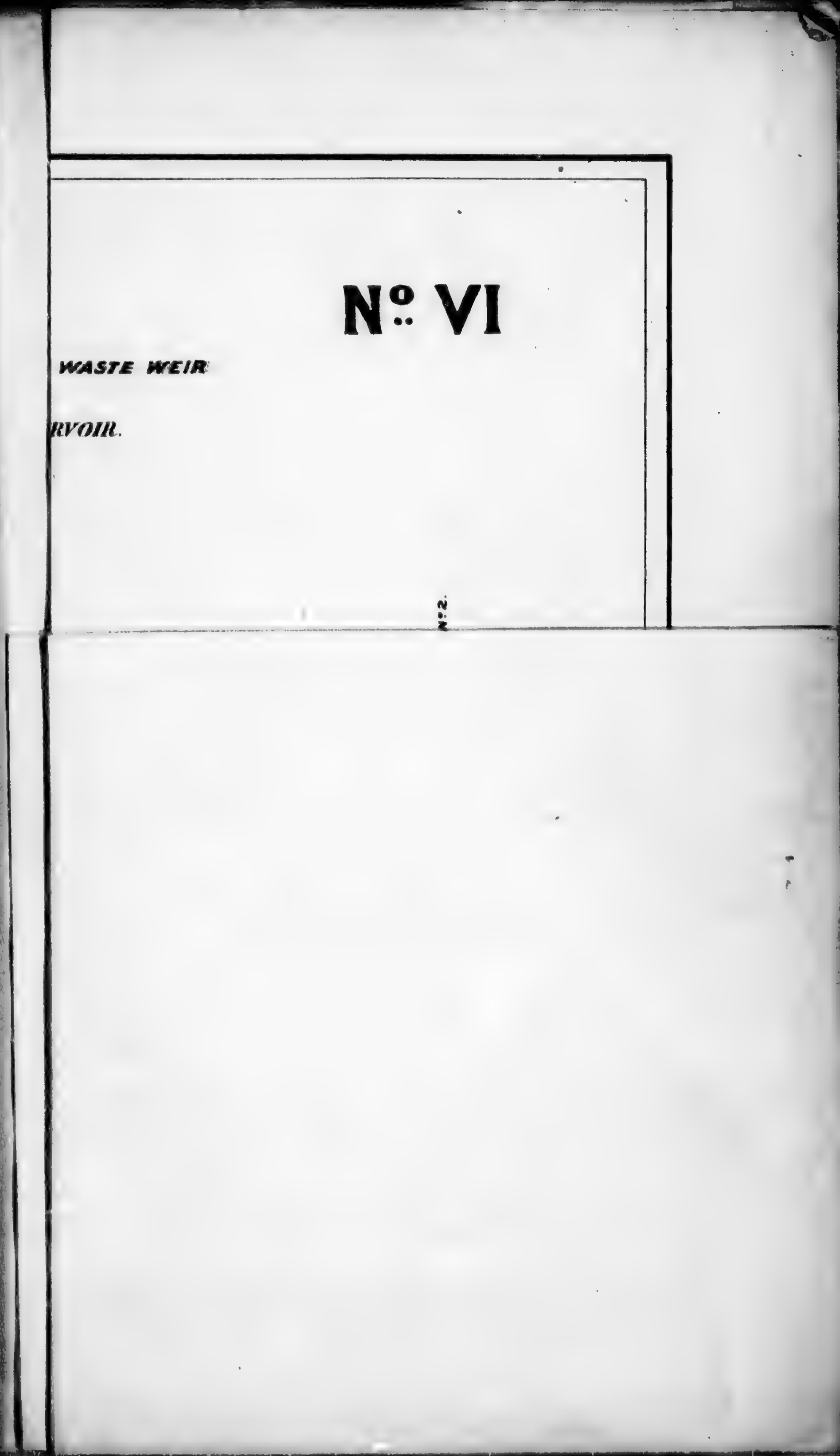


VICTORIA WATER SUPPLY

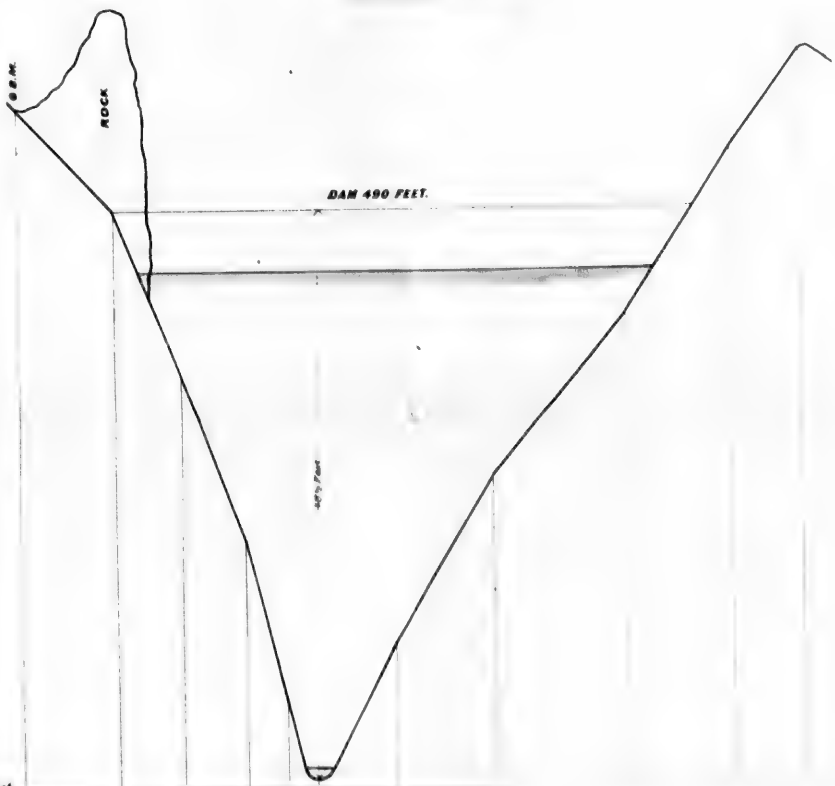
Comparative Sections of Dams.

Referred to in Mr. Bulkley's Report.

SECTION ON LINE OF DAM

AT

DEADMAN'S RIVER.



Datum Line 115 Feet above H.W.M. James Bay.

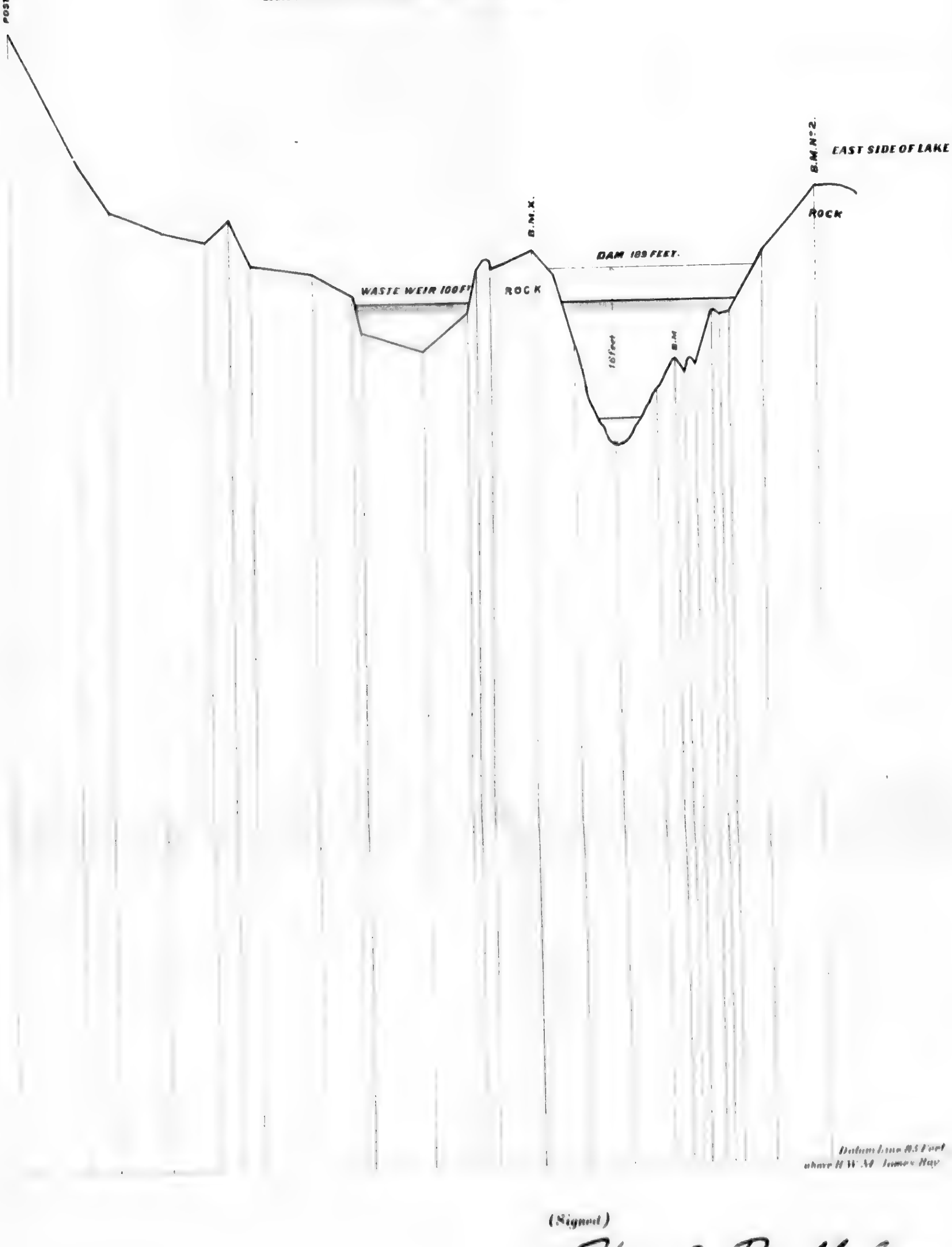
Horizontal Scale - 100 Feet to one Inch

Vertical Scale - 10 Feet to one Inch.

A. L. Bancroft & Co. Lith. S.F.

Nº VI

SECTION ON LINE OF DAM AND WASTE WEIR
AT
ELK LAKE STORAGE RESERVOIR.



Datum Line 83 Feet
above H.W.M. James Bay

- 100 Feet to one Inch.

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(Signed)
Thos. A. Bulkley
Chief Engineer to Government
British Columbia

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year's supply, at the rate of 25 gallons per head per day to a population of over (100,000) one hundred thousand.

It may be objected to this that the water of Beaver Lake is not of so pure a quality as that of Elk Lake, and that it would be more desirable to take the water direct from the latter.

Water cannot satisfactorily be taken from Elk Lake direct.

In answer to this I would say, that, irrespective of the additional two miles of pipe, which would be required, there are no satisfactory means for affecting this, unless at great expense for pumping, cutting or tunneling.

Again, the waters of both are, practically, the same; but that of Beaver Lake, having stagnated through a long stretch of willow swamp, has, when viewed in bulk, a slightly peaty tinge. This is not perceptable when the water is placed in a bottle, and entirely disappears in the overflow stream a short distance below the outlet. Indeed the self-purifying power of water in motion is well known; and peaty matter, although it might be classed as organic, possesses quite the reverse of putrifying properties.

No objection to the water running through and over the surface of Beaver Lake.

This objection, however, will entirely disappear under the proposal which I submit to you, which, as will be seen from the estimates, provides for the removal of the whole of the willow swamp before the formation of the reservoir, as well as for the construction of head works by which the water will be filtered before it is admitted into the conduit pipe.

Comparative analyses of various local waters.

Mr. Claudet has been good enough to undertake, at my request, a comparative analysis of the following samples of water which I forwarded to him.

SPECIMENS OF WATER.	Organic Matter in grains per gallon.	Mineral ingredients in grains per gallon.	Comparative Hardness.
1. Elk Lake water, unfiltered,.........			
2. Beaver do do			
3. Well water in town, unfiltered.....			
4. Water from Spring Ridge Company's service pipe, filtered.........			

I am not yet in possession of the result, but am quite confident it will be satisfactory as regards the quality of Elk and Beaver Lake waters.

The men of the survey party after using these waters for some weeks, found it vastly superior to any water they were able to obtain afterwards, while engaged in cutting the line into town.

How can we fill our storage reservoir?

With regard to the means at our disposal for filling the reservoir: I estimate the area of the watershed, or gathering ground, at 2,616 acres.

The registered annual rainfall at the Fisgard Lighthouse is nearly 24 inches.

Rainfall at least 24 inches.

According to all meteorological experience the rainfall, in the hilly district around Elk Lake, should be considerable more than this; but to be

on the safe side, I will estimate it at only 24 inches; of which, having regard to the rocky character of the gathering ground, I assume 75 per cent. to be available, or, in other words, that of the two feet of rainfall, one and a half feet finds its way into our storage reservoir; excepting the fall over the reservoir itself, of which, the whole is available for storage.

75 per cent. of rainfall is available for storage.

With regard to the amount of water annually lost by evaporation; no data have as yet been generally accepted from which this can be accurately ascertained. In tropical climates evaporation has been recorded as high as five feet in the year. One authority has stated that, in temperate climates, the loss by evaporation may be assumed to be counterbalanced by the deposit of dew. Mr. Hawksley states that the loss by evaporation varies between 9 and 16 inches.

A loss of two feet is allowed for evaporation from surface of reservoir and for leakage.

To be again on the safe side, I estimate the loss in each year, from the proposed reservoir, by evaporation and leakage, at 24 inches, or equivalent to the rainfall over the same area. So that to allow for evaporation it will be sufficient to omit the reservoir from the area of the gathering ground.

The rain fall gives us a nett supply for 90,000 inhabitants.

Head of supply above H. W. M. in Victoria is 190 feet.

Deducting, therefore, 589 acres from 2,616 acres, we have a gathering ground of 2,027 acres, with an available rainfall of 18 inches, yielding a supply in each year of over 827 millions of gallons, with a mean elevation of 190 feet above high water mark in Victoria—sufficient, at the rate of 25 gallons per head per day, for a population of over 90,000.

see P 10

Line of Pipes.

Having completed the general survey work in the neighbourhood of the lakes, the next step was to fix upon a line along which the water could best be conveyed from the dam to its destination: and for this purpose cast iron piping is the material which I recommend.

Very favourable line has been found.

I had at first expected it might be necessary to follow the valley line of the Colquitz in bringing the pipes into town; however, after spending a good deal of time and labour, I considered myself fortunate in finding such a convenient line as that which I have adopted, and shown on the plan.

Only 5 miles and 522 yards, length of main conduit pipes.

This gives a length of only 5 miles, 522 yards, from the Dam to the Bridge Tavern, at the commencement of Douglas Street, and is in every way more favourable than I had ventured to hope for. Indeed, I should imagine it might, at some future time, be selected for the construction of a road, as the levels are good and the saving in distance, as compared with the existing Saanich road, is half a mile between Douglas Street and the Royal Oak.

The line of pipes, shown blue on plan, joins the Saanich road opposite Dr. Tolmie's farm, so as to avoid the interference with any of the more valuable private lands in the vicinity of the city.

Line has been permanently laid down.

The whole of this line has been permanently laid down and cut out through the bush, and is so much work done against the laying down of the pipes.

Cast Iron is the material recommended for pipes.

I have mentioned above that cast iron piping is the material which I recommend for conveying the water into town. I have, however, been in

communuination with Mr. S. Howe, Secretary of the "Washington Water Pipe Manufacturing Company," at Olympia, with reference to the cost and strength of the wooden pipes which they offer to supply.

The following is an extract from a letter I have received from Mr. Howe, dated October 16th, 1872:—

"We manufacture 6, 4 and 2 inch pipe, and have not yet manufactured any of larger bore than these dimensions. We have an eight inch auger, but have not used it thus far. We are laying pipe of the bores mentioned, some with the bark on not requiring much pressure, say not exceeding, for six inch, more than thirty feet pressure, and for the other sizes not exceeding sixty feet. We can furnish at this place six inch, with the bark on, at twetny-seven cents per running foot; four inch, eighteen cents, and two inch at twelve and one-half cents, by the quantity. The coupling is turned on the pipe and costs no additional expense. The banded pipe we make from two to six inches; it costs considerably more. We band it to suit the pressure required, and coat the pipe with asphaltum and coal tar, so as to cover the outer surface and protect the bands from rust, and preserve the wood from decay. We can furnish the six inch to stand one hundred and fifty feet pressure, or less, for seventy-five cents per foot; four inch for fifty cents, and two inch for twenty five cents per running foot. The durability of this pipe we only know from tests elsewhere. It has been laid down in the States for fifteen years past, and given good satisfaction. We are prepared with the necessary machinery to make it, and we feel satisfied can give good satisfaction."

No saving in wooden pipes, even in first cost.

No quotation is given of the cost of 9 inch pipes, but judging by the prices for pipe of smaller diameters, I do not suppose that they could be supplied of sufficient strength to resist the required head for less than $1 25 per foot, at which prices there would be no saving on the cost of cast iron.

Conduit Pipe to be 9 inches in diameter, and will deliver a supply for 10,000 persons.

I have, therefore, estimated for a Conduit Main, of cast iron socket pipes, 9 inches internal diameter, with 7-16ths of an inch thickness of metal.

Assuming the pressure of water in town to be only 100 feet above the average level of discharge, and the central point of supply to be 6 miles from the Reservoir, this pipe will give a theoretical delivery of 22,393 gallons* per hour, equivalent to a supply for 10,000 Inhabitants, per day of 12 hours.

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* Hawksley's formula for the discharge of water pipesunder pressure is as follows:—

$$q = \sqrt{\frac{h}{l}(15d)^5}$$

where q = quantity discharged in gallons per hour = ?
l = length of pipe in yards ...... = 10560.
h = head of water in feet ...... = 100.
d = diameter of pipe in inches = 9.

then $q = \sqrt{\frac{100}{10560}(15x9)^5}$ = 20606 gallons per hour.

Beardmore's formula for ascertaining the same is:—

$$q = \sqrt{\frac{\frac{c}{l}}{h}}$$

where q = quantity in cubic feet per minute = ?
C = tabular number = for 9 in. pipe 1147.61.
l = length of pipe in feet = ... 31680.
h = head of water in feet .... 100.
then q = 64.476 c. ft. per min. = 24180 gallons per hour.

I have assumed the mean of these two results as the quantity which will be delivered through our 9 inch main.

It will be understood that the draft of the entire day's supply will be made upon the pipes during about only 12 hours, and that in order to avoid distributing Reservoirs in or near Town, the size of the pipe must be regulated accordingly.

Smaller pipe than 9 inches not recommended.

By reducing the pipe to an internal diameter of 7 inches and $\frac{3}{8}$ths thickness of metal, we should have a theoretical delivery barely sufficient for existing wants, and a saving would be effected on my estimate of about ten thousand dollars ($10,000). But this would, in my opinion, be a very false economy, and I strongly urge the adoption of the 9 inch main provided in my estimate.

Pipes will be laid in triplicate through the Dam.

In addition to the pipe at first proposed to be laid into town the estimates provide for two additional pipes being laid through the Dam, so that the supply may be extended, from time to time, without interference with the head works, as the increased population may require.

Distributing Reservoir in Town is not recommended.

The supply might, of course, be increased to some extent by constructing a distributing Reservoir in or near Town, so as to utilise the flow of the Pipe during the night when there is little draft upon the Mains for general supply. But by this means a portion of the "head" would be lost, and I should be in favor of an increase direct from the main Reservoir.

Present price of Iron is excessively high.

Unfortunately for the cost of the proposed works, the price of all iron work in England is, at the present time, remarkably high. Pipes which twenty years ago could be delivered for £5 per ton, would now cost from £9 to £10 per ton, and from all I can learn, there is not much chance of any improvement in the price. In addition to the main Conduit Pipe, we require pipes of various sizes for distributing the water throughout the Town. Here again the conditions are rather unfavorable; the streets are broad and long, while the houses, for the most part, are few and scattered.

Ten miles of Pipes is required for Town distribution.

It appears to me, however, that in commencing a new system of supply, the plan should be, to bring the water as much as possible within the reach of all, and, in order to do this, I cannot estimate the length of distributing Mains required at less than 17,543 yards, or say, 10 miles of pipe, of sizes varying between 9 inches and 2 inches in diameter.

Pipes are to be served with preservative coating.

It is customary now to coat water-pipes, while hot, with a preservative compound, with a view to retard the corrosion of the iron. The extra charge for this is only six shillings per ton, and is provided for in my estimate.

The arrangement of distributing Mains, and the proportion of Town Lots occupied by buildings, is shewn on Plan No. V.

Abstract of Estimated cost of Works.

An Estimate, in detail, of the cost of the proposed works is appended to this Report. The following is an abstract:—

Head Works	$14,120
Main Conduit Pipe, &c.	45,839
Town Distribution, &c.	23,181
Contingencies, Sundries, and Superintendence, 20 per cent	16,620
TOTAL COST	$99,766

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REDUCED SKETCH
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Old Road
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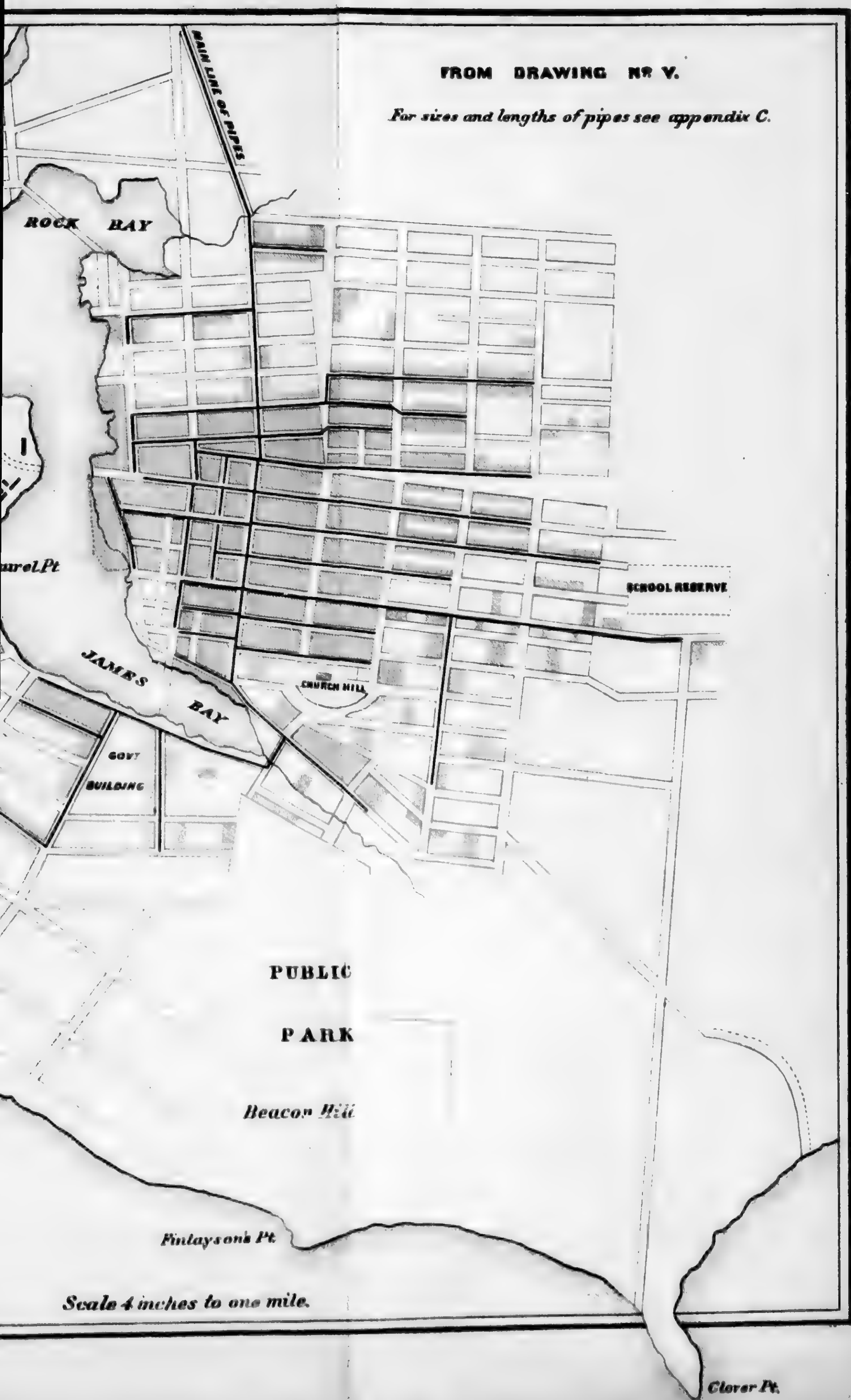
Shoal Pt.
Work's Pt.
JAMES
GOV'T BUILDING
Maclaughlin Pt.
Ogden Pt
Holland Pt.
(Signed)
Thos. A. Bulkley
Scale 4 inches t
A. L. BANCROFT & CO. LITH S.F.



FROM DRAWING Nº V.
For sizes and lengths of pipes see appendix C.
MAIN LINE OF PIPES
ROCK BAY
urel Pt
SCHOOL RESERVE
JAMES BAY
CHURCH HILL
GOV'T BUILDING
PUBLIC
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shewing the total cost to be less than $100,000, or less than $10, say £2, per head of Population provided for.

Cost per head of population supplied, compared with London Water-works.

The average cost of the works of the London Water Companies, was £2 8s. 7d. per head. If we had a demand at present for the whole amount of water which the Head Works are adequate to supply, the comparative cost per head would appear much more favorable; as it is, considering the very unsatisfactory state of the Iron market, I think the estimated cost of works is very moderate.

List of Plans and Sections.

The Plans, Sections, &c., accompanying this Report are as follows :—

No. I.—General Plan of the District, shewing position of various Lakes, and lines of Surface Drainage;

No. II.—Large Plan of General Survey from Elk Lake Valley to Victoria, showing gathering ground, proposed Reservoir, and line of Conduit Pipe;

No. III.—Section on line of Pipes;

No. IV.—Section on line of Road;

No. V.—Plan of Victoria, shewing lines of distributing pipe and proportion of Town Lots occupied with Buildings;

No. VI.—Comparative Sections on lines of Dams;

No. VII.—Detail designs for Dam and Waste Weir;

No. VIII.—Detail design for Filtering Tower;

No. IX.—Designs for crossings on main line of Pipe.

N. B.—Several of these are too large to attach to this Report in its printed form.

Levels are referred to high water mark in James' Bay.

The point to which the datum lines on the Sections, and the levels generally, are referred, is a bench mark at approximate high water mark under the North-west corner of James' Bay Bridge.

Plan of operation in commencing work.

These Plans, in conjunction with the quantities and estimates, will fully explain the proposed works. It may be well, however, for me to describe the plan of operation more especially with a view to the time of completion.

So soon as the work has been finally decided upon, the first step will be to order the whole of the main conduit and distributing pipes from Liverpool or Glasgow. The price of the pipes would be somewhat less in the latter place, but probably freight would be more favorable from the former.

Works should be completed in one year and a quarter.

I suppose the pipes could be landed in Victoria in nine months from date of order; in which case I think the water should be distributed in the Town within one year and three months. Supposing the pipes to be ordered in February, the next step will be to acquire the necessary Land, and so soon as the spring rains are over, to commence the clearing of the willow swamp and land to be submerged by the Reservoir, previously lowering the water in the Lakes about a foot below its natural level, by removing a temporary wooden dam, and sundry beaver dams, and blasting away a small amount of rock at the outlet.

The pipes and iron work required in the Dam and Filtering Tower would be obtained at the local Iron Foundry, so as to allow the Dam, Waste Weir, &c., to be completed by the fall of the year, and ready to store the winter rainfall.

We should then have, by the commencement of the Summer of 1874, if my calculations are correct, a Reservoir stored with an unlimited supply of good water, and means for distributing it throughout the City.

By whom are the Works to be undertaken.

One very important point which will have to be decided, is, "to whom is the work to be entrusted?" There may be said to be three agencies available:—

1st.—By direct Government control;

2nd.—By the Municipal Corporation of the City;

3rd.—By a Company of private Capitalists.

By Government.

The great objection to the two first appears to be, that special taxation or guarantee would be necessary, and that looking upon water as simply a marketable commodity, it is the result of experience that trading operations are better managed by private enterprise, than when under the control of Governments or Corporations.

By Corporation.

On the other hand it may be urged, with some show of reason, that in view of the many costly works of an unremunerative character which the City Corporation has before it, such as Drainage, Road making, Street lighting, &c., it would be only right that they should have, as a set-off against these, the benefit to be derived from any reproductive work such as Water Supply.

This, however, is a point upon which it is not necessary for me to make any recommendation, further than to state that an undoubted want is felt for a plentiful supply of good water, and if this want cannot be met in the ordinary course of demand and supply, then I would urge that the works be undertaken by Government or the Corporation, even at the cost of special taxation.

In the latter case an addition should, I think, be made to my estimate to cover the cost of laying the water within the property of every person taxed, say Six Hundred house services at $15, or about $7,000.

Or by Private Companies.

In the event of the work being entrusted to a Private Company, with a monopoly of sale for a certain number of years, then it will, of course, be necessary to fix the maximum charge to be levied for the water, and a limit of time both for the commencement and completion of the works. It would also, I think, be highly desirable to make some provision whereby the Company should *be bound* to extend their mains to the properties of persons, outside the system of pipes at present proposed, who may desire to avail themselves of the water; say in every case in which the water rent to be paid by such person would yield a return of eight per cent. upon the cost of the proposed extension.

"Will it pay?"

By whatever agency the work is undertaken, one question of interest will be "will it pay?" In estimating the amount of water at present required, I assumed the population to be Five Thousand. For the purpose of calculating the returns or probable income to be derived from the water, I will suppose the population to be Four Thousand, which is certainly within the mark.

Compared with San Francisco.

First to examine the case of our neighbours in San Francisco; I find from the published Share Lists that the "Spring Valley Water Company" has a paid up capital of $8,000,000, and that it pays a dividend at the rate of 6 per

cent. per annum: or, in other words, that it divides a nett profit of $180,000. Assuming the cost of superintendence and maintenance to be 20 per cent. of gross receipts, and the population supplied to be 150,000, it would appear that the annual average charge for water in San Francisco is $4 00 per head of population.

Return would be at rate of 12 per cent.

Taking this as a basis for the income to be derived from our own water, and allowing 25 per cent of gross receipts for superintendence, maintenance, and minor extensions, we have a nett profit of $12,000, or a return upon the estimated cost of works of 12 per cent. per annum.

Compared with "Spring Ridge Company."

Next to examine the charges of the "Spring Ridge Water Co.," to which Victoria at present owes its supply. And here I would express my thanks to the Directors and Secretary for the very courteous manner in which they have furnished me with information regarding the working of the Company.

Firstly. If we take the Company's charge upon *quantity*, viz, 75 cents per 100 gallons, and calculate the income to be derived from the quantity which I have proposed to supply, the returns would appear so favorable that perhaps I had better not put them in figures.

Secondly. Taking the present Company's charges as at so much per house:—It appears that 60 establishments are supplied by service pipes from which a monthly revenue is derived of about $400, and that some 300 houses are supplied by cart service, at an average charge throughout the year of about $2 per month. So that the average monthly charge per house supplied is $2 75 or $33 00 per annum.

Return would be at rate of 15 per cent.

Taking this rate of charge and assuming that we have 600 houses requiring a supply, and allowing as before 25 per cent. for maintenance, etc., there would be a return upon the estimated cost of nearly 15 per cent.

Lastly. Basing our calculations upon the *actual income derived by the existing Company at the present time*—and I need not dwell upon the fact of the inferior nature of the supply, nor upon the fact of the system being the most expensive that could be devised; the water having to be handled at least 5 times before it enters into consumption—

Or at the very lowest 9 per cent.

The amount paid to the present Company for water supplied will be seen from the figures given above to be $12,000 00 per annum. Allowing, as before, 25 per cent. per maintenance, etc., which is ample under the "gravitating" system, we should have at the lowest and most unfavourable estimate a return of 9 per cent. per annum.

Drainage must not be neglected.

While, however, urging upon Government the construction of works for an improved water supply, I should not be doing my duty if I omitted to point out that it will be of great importance at the same time to undertake works for the drainage of the city. If this is neglected,—if a plentiful supply of water is introduced, and no attention given to provide means for disposing of it after use,—the result, according to all experience, will be an increased death rate.

The valley extending from the head of James Bay, toward Ross Bay appears to offer a good line for an Outfall Sewer; but surveys would be required before a definite opinion could be given. It is certain, however, that if Victoria is expected to become a

populous city, the outfall should *not* be into the harbour. Even already, I believe, the deposit caused by the washings of the streets, etc., has sensibly lessened the depth of water along the principal wharf frontage.

I trust that I have put the water question before you in a satisfactory light, and I regret that the repairs to the Alexandra Bridge, which necessitated my absence for a month from Victoria, should have prevented my submitting this report quite so early or in so complete a form as I could have wished.

Are the requirements fulfiled by the Elk Lake Reservoir project?

Glancing back to the "requirements" which I proposed, I think you will find they are fulfiled in the project which I recommend.

As regards "quality," I am satisfied of the excellence of the proposed supply, The analysis alone is wanting to place it beyond doubt.

As regards "quantity," the supply at first is for 10,000 and capable of extension, by simply the addition of extra pipes, to meet the wants of 90,000 inhabitants.

The supply is on the most economical system of "gravitation," and is derived from a reservoir with a head of 192 feet above high water mark in Victoria.

The cost of the Works is within the moderate sum of $100,000, upon which the income, calculated at the *lowest figure*, would yield a nett return of 9 per cent.; a return which would increase very rapidly in proportion to the growth of the city.

I think Victoria may be congratulated upon having such an abundant supply of water, so easily obtainable, and I hope I may see the day when it is all required.

I have the honor to be, Sir,

Your obedient servant,

THOS. A. BULKLEY,

Chief Engineer to Government, British Columbia.

October 28th, 1872.

APPENDIX A.

VICTORIA WATER WORKS.

ESTIMATE of Total Cost of Works for Supply from Elk Lake Storage Reservoir.

No.	Description of Work.	Quantity.	Rate.	Per.	Amount.
	HEAD WORKS.				
	Impounding Dam, of best Uncoursed Rubble Masonry, set in approved Hydraulic Mortar and Faced with picked stones All external joints carefully pointed with Portland Cement. Headers or bond stones not less than 2½ feet in length inserted through the work at distances of not more than 3 feet vertical, and 6 feet horizontal: including preparing foundation and blasting bed-rock where directed, to obtain a clean surface for Masonry........Cubic Yards	550	$ 5 00	c. yd.	$ 2,750
	Paving and Coping to surface of Dam, of cut stone from Newcastle Island, or other approved Quarry, including setting in Portland Cement........Cubic Feet	425	2 00	c. foot.	850
	Waste Weir.—Uncoursed Rubble Masonry, same as for Dam Cubic Yards	100	5 00	c. yd.	500
	Cut stone in Coping and Lip for Waste Weir, same as in Coping for Dam........Cubic Feet	212	2 00	c. foot.	424
	Clearing overflow Channel from Waste Weir to old bed of Stream. say,	....	....	....	100
	Filtering Tower.—Coursed Rubble Masonary set in Portland Cement, mixed in the proportion of one of Sand to one of Cement........Cubic Yards	26	12 00	c. yd.	312
	Cast Iron lining to Tower, including fixing........Tons	1¾	....	....	350
	Cement Concrete for Tower........Cubic Yards	1	10 00	c. yd.	10
	Filtering Materials, washed and placed........Cubic Yards	12	2 50	c. yd.	30
	Roof and Gangway to ditto........say	....	....	....	80
	Laying Main Pipe in triplicate through Dam, including fixing, 24 feet 9 inch pipe; 24 feet 12 inch pipe; and 24 feet 15 inch pipe, to be cast in Victoria........Tons	3½	....	....	700
	Screw Valves for ditto, four in number, with Gun Metal faces, screws, and nuts, 2 of 9 inches; 1 of 12 inches; 1 of 15 inches say	....	....	....	500
	Inspectors Cottage, Tool House, and Tools........	....	....	....	1,000
	Diversion of East Saanich Road........Miles	½	600 00	mile.	300
	Clearing Land of Willow Swamp, burning wood, &c........Acres	86	30 00	acre.	2,580
	Dry Land to be submerged by Reservoir; compensation and cost of partial clearing........Acres	91	40 00	acre.	3,640
	Cost of Head Works........$14,126				
	MAIN CONDUIT PIPE.				
	Five miles, 532 yards of Cast Iron Socket Pipes; 9 inches internal diameter; 7-16ths of an inch thickness of metal. 9,322 yards, at 134 lbs. per yard, = Tons, 557½. Estimated Cost of One Ton:— Prime Cost F. O. B. in England, per Ton......$47 00 Extra for Preservative Coating ,, ... 1 50 Freight to Victoria, per Ton........ 15 00 Insurance ,, ... 1 50 Import Duty ,, ... 7 25 Wharfage ,, ... 50 Total Cost per Ton delivered......$72 75 Tons	557½	72 75	ton.	40,558
	Cost of laying Main, including carting pipes, opening trench, not less than 2½ feet deep, lead, labor, &c., and refilling trench. Lineal Yards	9322	50	c. yd.	4,661
	Carried forward........	....	....	....	59,345

APPENDIX A.—*Continued.*

No.	Description of Work.	Quantity.	Rate.	Per.	Amount.
	Brought forward	....	....	....	59,345
	MAIN CONDUIT PIPE.—*Continued.*				
	Special crossings on line of Pipe; 2 at $100, and 4 at $50...........	....	....	....	$ 400
	Right of way for Pipe through private property 12 feet in width on length of 6,543 yards..Acres	5½	$40 00	acre.	220
	Cost of Main Conduit Pipe.........$45,839				
	TOWN DISTRIBUTION.				
	Ten miles (nearly) of cast iron socket pipes, of various sizes and weights, as follows:				

Size of Pipe.	Thickness of Metal.	Length of Pipe.	Weight per Yard.	Total Weight.
9 inches.	7-16ths in.	600 yards.	134 lbs.	80,400 lbs.
8 "	7-16ths "	150 "	121 "	18,150 "
7 "	7-16ths "	217 "	106 "	23,002 "
6 "	⅜ths "	200 "	78 "	15,600 "
4 "	⅜ths "	1,833 "	53 "	97,149 "
3 "	5-16ths "	2,213 "	35 "	77,455 "
2½ "	¼th "	6,893 "	21½ "	148,199 "
2 "	¼th "	5,437 "	17½ "	95,147 "
Total length, yards......		17,543 yards.	Total Weight	555,102 lbs.

No.	Description of Work.	Quantity.	Rate.	Per.	Amount.
	Total weight, 555,102 lbs., or say......................................Tons	247¾	80 00	ton.	19,800
	Cost of laying Pipes throughout the Town, including carting pipe, opening and refilling trench, labour, lead, etc.; top of pipe to be not less than eighteen inches below the surface of ground ....Yards	17543	15	yard.	2,631
	Pipe bends and joints at branches....................................Number	50	15 00	each.	750
	Cost of Town distribution.........$23,181				
	Contingencies and Superintendence, at 20 per cent......................	....	....	....	16,620
	Grand Total..	....	....	....	99,766

ABSTRACT.

Head Works..	$14,126 00
Main Conduit Pipe, etc..	45,839 00
Town Distribution, etc..	23,181 00
Contingencies and Superintendence....................................	16,620 00
	$99,766 00

Say $100,000.

THOS. A. BULKLEY,
Chief Engineer to Government,
British Columbia.

APPENDIX B.

VICTORIA WATER SUPPLY.

Table showing the height of various points in Victoria above approximate High Water Mark under James Bay Bridge.

NAME OF STREET.	Elevation above High Water Mark James' Bay
Government Street, opposite Humboldt Street	26 Feet.
" " " Courtenay "	37 "
" " " Broughton "	41 "
" " " Fort "	46 "
" " " Bastion "	51 "
" " " Yates "	50 "
" " " Johnson "	44 "
" " " Pandora "	44 "
" " " Fisgard "	44 "
" " " Herald "	39 "
" " " Chatham "	29 "
" " " Discovery "	18 "
" " Bridge at Gas Works	15 "
Fort Street, opposite Broad Street	52 "
" " " Douglas "	55 "
" " " Blanchard Street	67 "
" " " Quadra "	68 "
" " " Vancouver "	60 "
" " " Cook "	65 "
" " " Capt. Ella's house	93 "
" " " Moss Street	126 "
Yates Street, opposite Broad Street	57 "
" " " Douglas "	60 "
" " " Blanchard "	71 "
" " " Quadra "	63 "
" " " Vancouver "	65 "
" " " Cook "	69 "
Pandora Street, opposite Broad Street	49 "
" " " Douglas "	55 "
" " " Blanchard "	62 "
" " " Quadra "	73 "
" " " Vancouver "	83 "
" " " Cook "	89 "
The late Female Infirmary	134 "
Church Hill	80 "
Upper Balcony of Driard's Hotel	115 "
Plinth of Government House	159

T. A. B.

APPENDIX C.

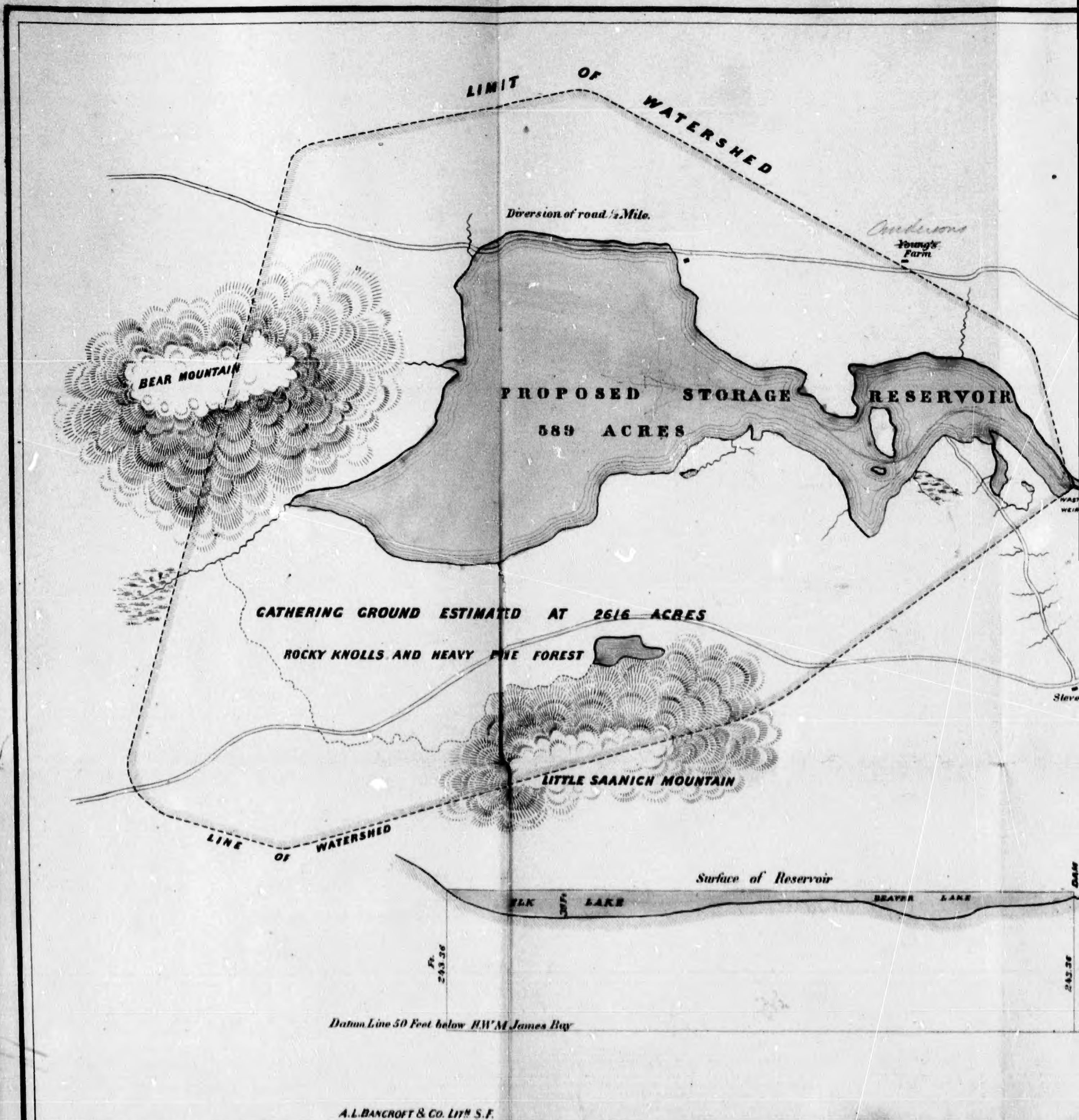
VICTORIA WATER SUPPLY.

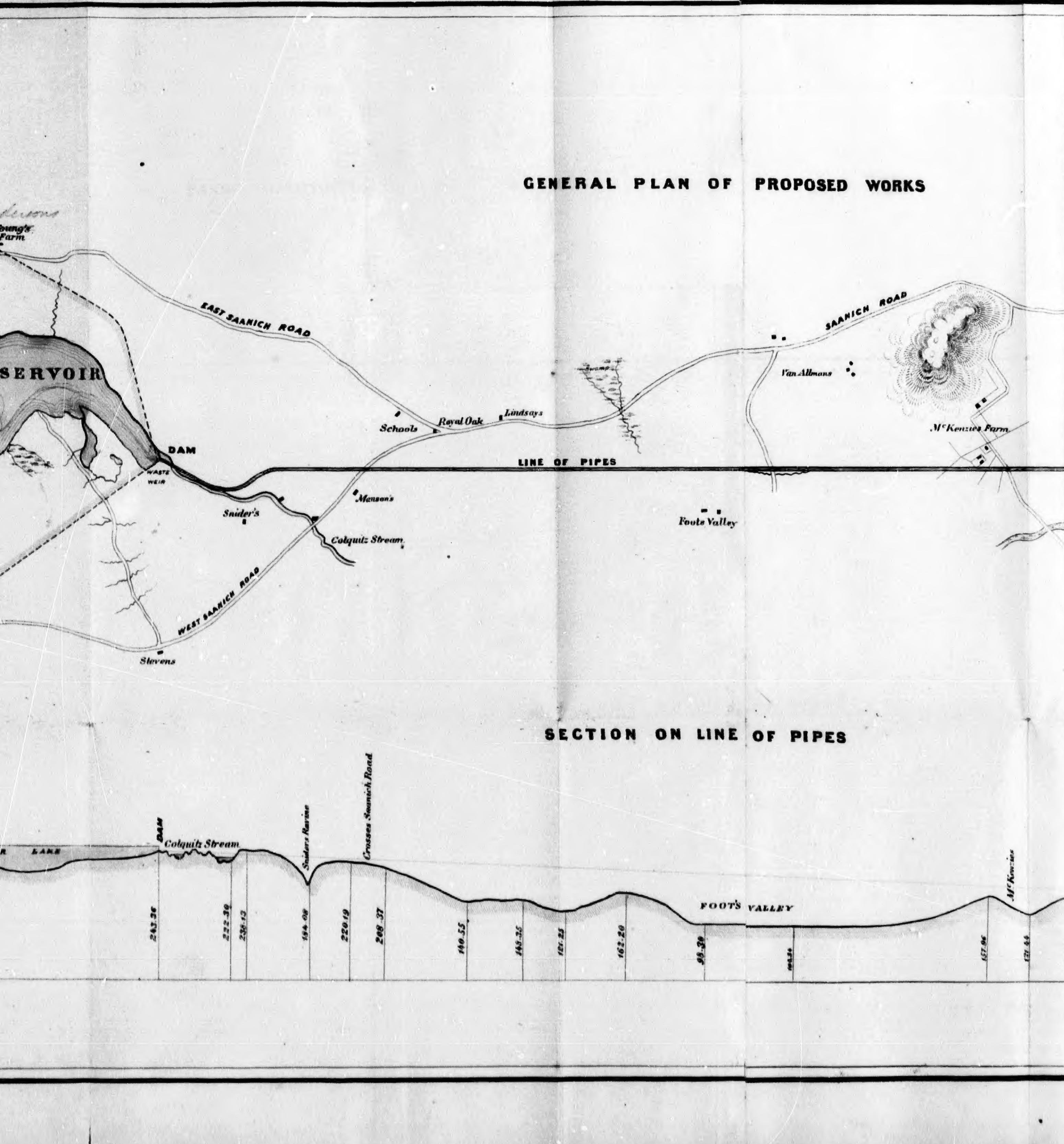
Table showing lengths and diameters of distributing mains throughout the Town.—Vide Plan No. V.

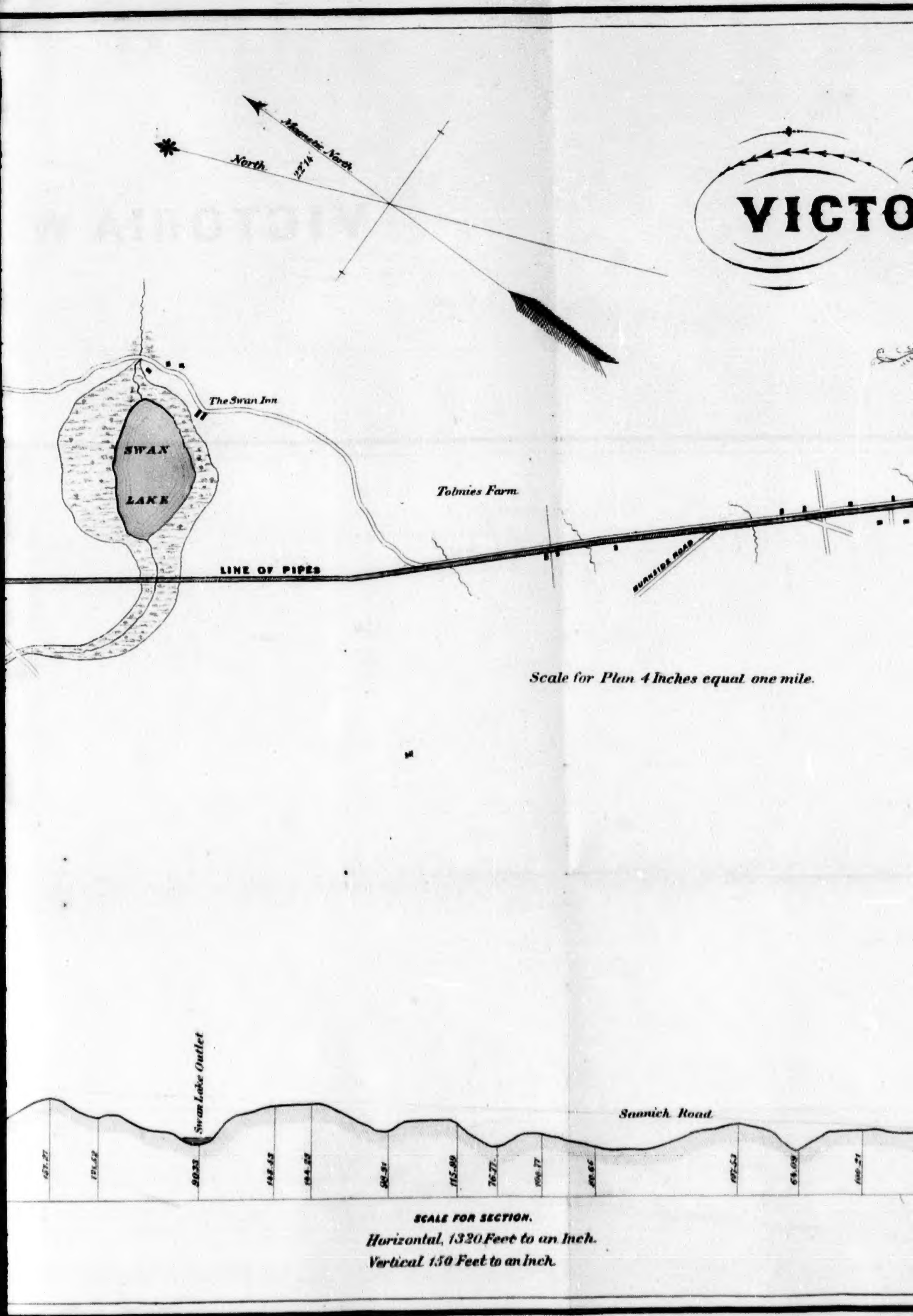
Name of Street.	Internal Diameter of Pipes in Inches.								Total length of Pipes in feet.
	2 in.	2½ in.	3 in.	4 in.	6 in.	7 in.	8 in.	9 in.	
DOUGLAS STREET.—Bridge Tavern to Humbolt Street				900	600	650	450	1800	4,400
Branches on West side Douglas Street.									
Discovery street		1,220							1,220
do. Branch in Store street	250								250
Fisgard street		1,220							1,220
do. Branch in Store street	200								200
Cormorant street		1,220							1,220
do. Branch in Government st.	320								320
do. do. Store street	200								200
Pandora street	500								500
do. Branch in Broadway	250								250
Johnstone street		1,180							1,180
do. Branch in Broadway	300								300
do. do. Government st.	300								300
Yates street			1,300						1,300
do. Branch in Government st.	530								530
do. do. Langley street	550								550
do. do. Wharf street		850							850
View street	320								320
Branches Broadway	450								450
Fort street		630							630
Branch Government street	450								450
Kane street	550								550
Rae street	550								550
Humbolt street	580								580
Branch on East side Douglas Street.									
Prince's street		760							760
Fisgard street	460		640						1,100
Branch Blanchard street		300							300
do. North Park street	1,250	700							1,950
Cormorant street	1,280								1,280
Pandora street	1,320	1,300							2,620
Johnstone street	1,350	1,300							2,650
Yates street		1,300	2,000						3,300
View street	650	1,300							1,950
Fort street		1,050	1,250	2,050					4,350
Branch Vancouver street		1,450							1,450
Kane street	1,300								1,300
Rae street	1,300								1,300
Humbolt street	1,100			750					1,850
JAMES' BAY		1,800		1,800					3,600
Bird-cage Walk		1,200							1,200
Menzies street			1,450						1,450
Branch Quebec street		800							800
do. Michigan street		1,100							1,100
Lengths in feet	16,310	20,680	6,640	5,500	600	650	450	1800	52,603

T. A. B.

ATER SUPPLY


LIMIT OF WATERSHED
Diversion of road ½ Mile.
Andersons
~~Young's~~ Farm
BEAR MOUNTAIN
PROPOSED STORAGE RESERVOIR
589 ACRES
GATHERING GROUND ESTIMATED AT 2616 ACRES
ROCKY KNOLLS AND HEAVY PINE FOREST
LITTLE SAANICH MOUNTAIN
LINE OF WATERSHED
Surface of Reservoir
ELK LAKE
BEAVER LAKE
DAM
Ft. 243.36
243.36
Datum Line 50 Feet below H.W.M. James Bay
A.L. BANCROFT & Co. LITH. S.F.

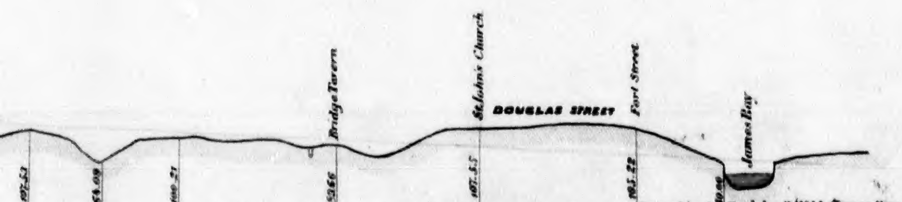

GENERAL PLAN OF PROPOSED WORKS
Young's Farm
EAST SAANICH ROAD
SERVOIR
DAM
WASTE WEIR
Snider's
Manson's
Colquitz Stream
Schools
Royal Oak
Lindsays
LINE OF PIPES
SAANICH ROAD
Van Allmans
McKenzies Farm
Foots Valley
WEST SAANICH ROAD
Stevens
SECTION ON LINE OF PIPES
LAKE
DAM
Colquitz Stream
Sniders Ravine
Crosses Saanich Road
FOOT'S VALLEY
McKenzies
243.36
222.30
236.13
194.08
220.19
208.37
140.55
148.35
151.25
162.20
98.30
157.96
131.44
151.71



VICTO
North
Magnetic North
22°14'
The Swan Inn
SWAN
LAKE
Tolmies Farm
LINE OF PIPES
BURNSIDE ROAD
Scale for Plan 4 Inches equal one mile.
Swan Lake Outlet
Saanich Road
SCALE FOR SECTION.
Horizontal, 1320 Feet to an Inch.
Vertical 150 Feet to an Inch.

VICTORIA WATER SUPPLY

REDUCED FROM DRAWINGS Nos 2&3.



(Signed.)

Thos. A. Bulkley

Chief Engineer to Government
British Columbia.